

Beach Management Plan

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Scheme Name	Chesil Beach (Portland to Small Mouth) Management Plan
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View north-westwards along Chesil Beach at Chiswell (15th January 2014)

Date	07 October 2015
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Version	2.0
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Chesil Beach (Portland to Small Mouth) Management Plan

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Chesil Beach is an iconic feature of the Dorset Coast and the UNESCO Dorset and East Devon World Heritage Coast (the 'Jurassic Coast'), being designated for its unique geological and geomorphological features. Chesil Beach is a linear, swash-aligned, shingle barrier beach that extends from Portland in the east to West Bay harbour in the west. It is extensively designated for its environmental features. Designations include SAC, SPA, SSSI, Ramsar and MCZ.

The area of interest for this Beach Management Plan (BMP), which is the first revision of the BMP originally produced in November 2010, is at the south-eastern end of Chesil Beach from Chiswell at Portland to opposite Small Mouth (see **Figure EX.1**). Behind the beach is an area of low-lying extensively developed land at Chiswell that is at risk of flooding (see **Figure EX.2**).

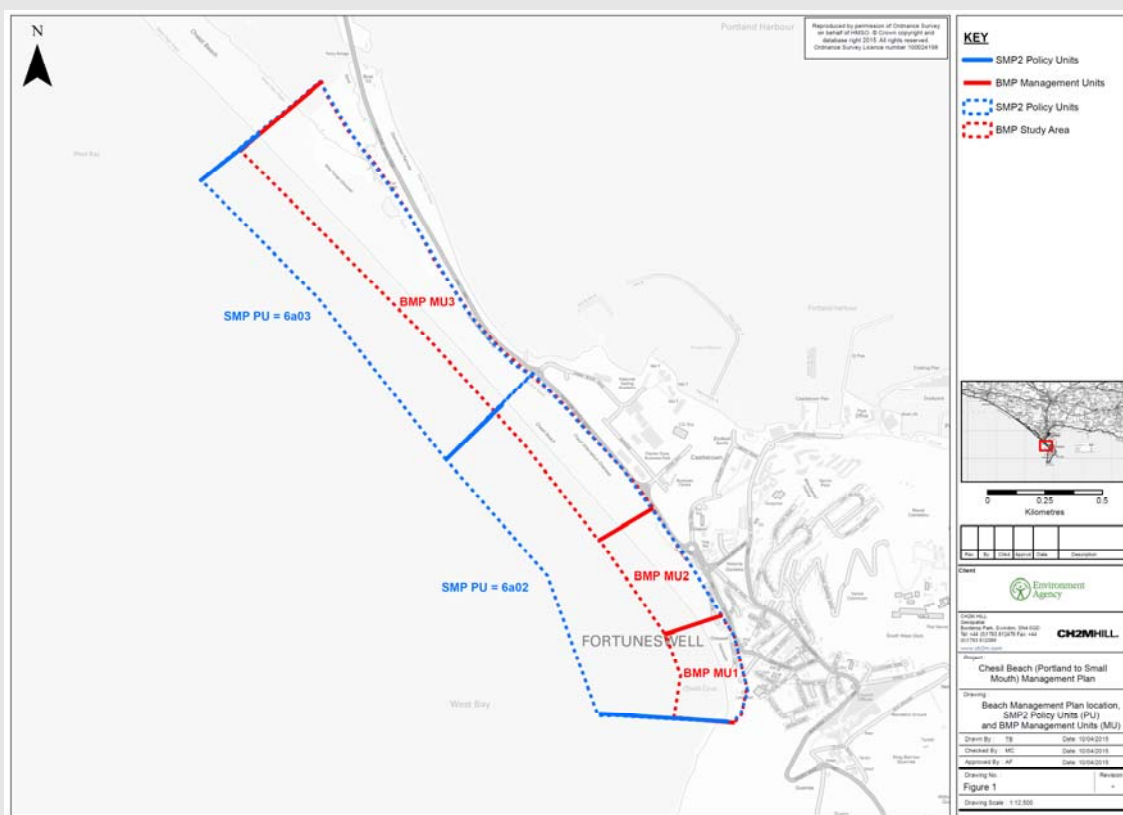


Figure EX.1 BMP extent, including BMP Management Units and SMP2 Policy Units.

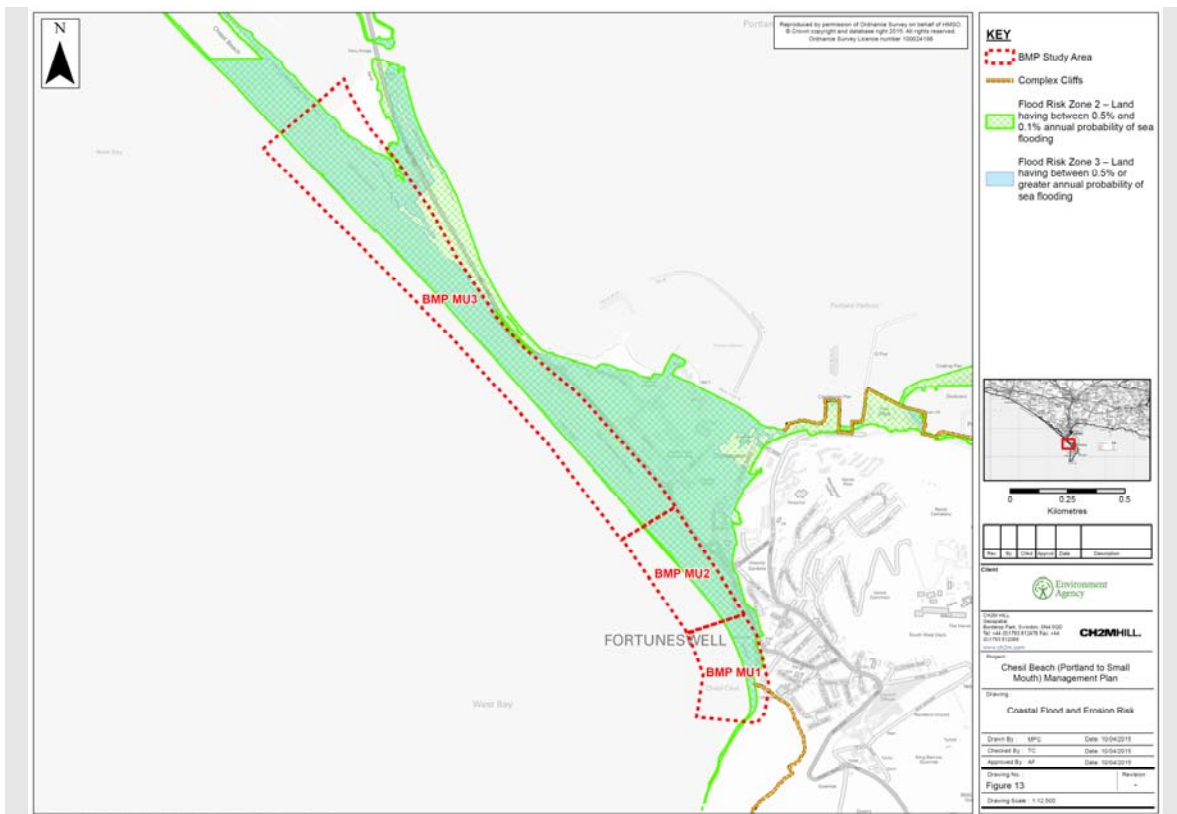


Figure EX.2 Flood and erosion risk areas.

Many flood events have occurred here in the past and, following two successive flood events in late 1978 and early 1979, a capital scheme was constructed in the mid-1980's to reduce flood risk. This scheme involved the construction of an enhanced seawall (upgrading the original seawall constructed in the 1960s) and promenade; a gabion castle and mattress to stabilise the beach crest; and an interceptor drain within the beach with a flood alleviation channel to divert water coming through the beach into Portland Harbour to the east of the beach. The interaction between these hard defence structures and the beach, which are maintained by the Environment Agency and Weymouth & Portland Borough Council (WPBC), is vital to providing protection against flood risk. The north-western part of the BMP area towards Small Mouth is comprised of undefended naturally functioning beach behind which lies the only access route to the Isle of Portland – the A354 Portland Beach Road. Should the beach in this area roll back in the future it could impact upon this key transport route.

In addition to the defences that reduce the risk of coastal flooding, at the south-easternmost end of the BMP area, a coast protection scheme constructed in the 1960s comprised of slope stabilisation measures and a seawall, serves to reduce the risk of coastal erosion and landsliding in the West Weares cliffs that rise up from the sea in this area. These defences are maintained by WPBC.

Currently the defences along this frontage (see **Figure EX.3**) protect approximately 170 residential and commercial properties at Chiswell with a capital value of around £17 million. This value does not include the economic value of the A354 road and other assets such as those constructed in recent years in the Osprey Quay area.

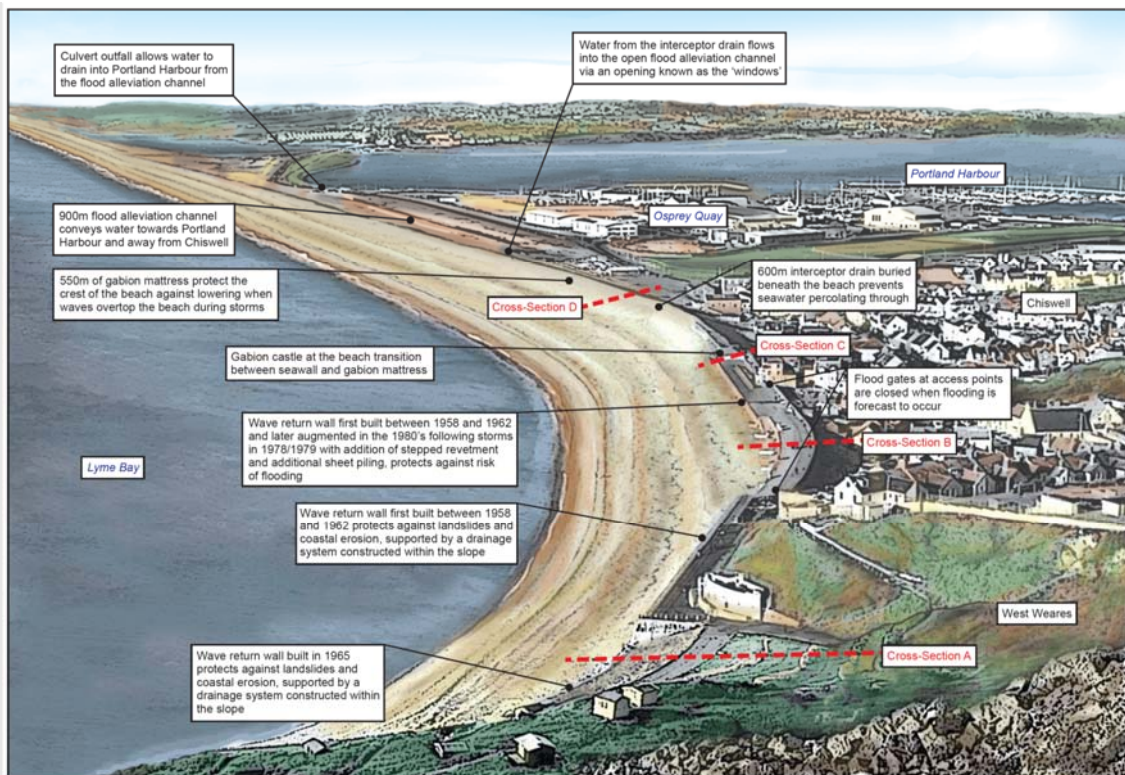


Figure EX.3 Overview of the coastal defence system along the BMP frontage.

The aim of the BMP, which has been developed utilising the best practice contained in the CIRIA Beach Management Manual (second edition), is to inform, guide and assist the responsible authorities and organisations in managing the beach to reduce the risk of coastal flooding and erosion whilst recognising and managing the implications for the many environmental designations of the site.

The key objective of this BMP is therefore to manage the risk of coastal flooding, erosion and landsliding by ensuring that an adequate beach is maintained along the south-eastern end of the BMP area towards Chiswell and that the various hard-defence structures are maintained in good order, such that the Standard of Protection (SoP) of the scheme is retained and the risks are minimised.

The current SoP for coastal flood risk has previously been stated as being in the range at 6.7% to 10% annual probability of occurrence (APO) (1 in 10 to 1 in 15 year return period) against overtopping and breaching (Environment Agency, 2009a). However, there is much uncertainty about the definition of SoP for the coastal defences in the BMP area, particularly given the performance of the defences during the winter 2013/14 storms that have been assessed to have been well in excess of the SoP levels (refer to **Section 1.4.1**). This uncertainty is due in part to a lack of long-term high-quality quantitative monitoring data being available for this site covering the complex interactions between waves, wind, tide, water level within the beach (linked to beach porosity) and beach morphology which are not well understood (refer to **Section 1.4.4**).

As such, the BMP objective is to ensure that the integrity of the defences is maintained such that they are able to perform in a similar way as they did during the sequence of extreme storm events experienced during the winter of 2013/14. To achieve this objective, the BMP sets out the strategy

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for monitoring and intervention to maintain the beach, hard defence structures and slope stabilisation measures to ensure the coastal defence system continues to provide protection against the risk of coastal flooding, erosion and landsliding at Chiswell. It also includes consideration of the likely options available for carrying out Crisis Level Works should Chesil Beach be overtopped, overwashed or even breached during a large wave event and threaten the A354 Portland Beach Road in particular (refer to **Section 5**).

The main recommendations in the BMP therefore seek to continue the current practice of occasional beach recycling and re-profiling to help maintain the integrity of the overall sea defence system at Chiswell, supported by ongoing maintenance of the hard defence structures along the BMP extent. This will be further supported by efforts to capture a much greater amount of monitoring data, and additional routine analysis of that data, to improve the understanding of coastal processes and how this relates to flood risk in this area. To aid this, changes to how post-storm (and possibly pre-storm) surveys are triggered is recommended, as is monitoring of additional beach parameters such as beach crest position and crest width above defined levels.

In addition, there are also a number of areas where further investigation identified in this BMP could be undertaken at a more academic level. Such investigations as part of research projects, possibly undertaken in conjunction with Universities and Research Councils, would both contribute to the understanding of coastal processes and associated flood risks as well as benefit from the greater amount of monitoring recommended in this BMP (see **Appendix F**).

Due to the lack of adequate data on which to base understanding, it is not possible at this time to provide robust evidence-based trigger levels that are based on assessment of changes to the SoP to inform when 'Action Level' or 'Crisis Level' works should occur. Therefore, whilst the increased programme of monitoring recommended in this study is being implemented, the current maintenance practices of occasional beach recycling and re-profiling will be continued in Management Units 1 and 2 (MU1 and MU2). This will be informed by comparison of beach level against the seawall crest level to the seawall toe levels in MU1, and the toe level of the gabion castle and mattress in MU2. Works in MU3 will only occur if required to restore (a) the capacity of the flood alleviation channel if it is infilled by shingle as a result of 'cannots', and/or (b) the defence function of the beach should crest lowering and overwashing (or even breaching) of the beach occur as a result of a large wave event. Otherwise this area will be allowed to continue to evolve naturally.

Investment in the actions identified in this BMP (see the 'Action Plan' in **Section 6**) to improve understanding of the site behaviour will enable this situation to be revised when the BMP is reviewed in five years' time. Then more data will be available to inform understanding of coastal processes. This will enable more appropriate, timely, effective and efficient management practices to be established and implemented. At this time it may be possible to derive further trigger levels based upon assessment of changes in the SoP.

Whilst the management works defined in this BMP are undertaken to try and ensure that the overall sea defence system at Chiswell is adequately maintained to achieve the BMP aim, it is important to recognise that beach management and maintenance of the hard defence structures alone can only provide protection to parts of Chiswell under relatively small locally generated (wind) and swell wave events.

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If a large locally generated (wind) or swell wave event were to occur, as has happened historically, then it is unlikely that the defences here will provide protection against flooding. Indeed, there is potential for catastrophic and rapid inundation should overwashing occur as a result of a large swell wave event. Analysis suggests that waves with a period of about 18 seconds or more pose the greatest risk (refer to **Section 3.2.4**). Whilst it is possible to track such swell waves it is not possible to accurately predict the impact on Chesil Beach from a flood warning perspective.

As a result, there is a reliance on flood warning procedures to be able to provide adequate warning time to evacuate flood risk areas should a large event be predicted. However, there are a number of issues that have been identified with the data utilised for flood warning purposes at Chiswell, which the Defra/EA *Understanding Barrier Beaches* R&D report (2008) describes as being a low key and largely ineffective flood forecasting system.

Linked to the uncertainty about coastal processes, there is presently insufficient data available to understand these large events and how they may impact upon Chesil Beach and the low-lying land it protects. There is also no reliable means to accurately predict the likely impacts of such events at Chiswell to give adequate flood warning. Therefore it is vital that emergency plans are robust and set out the measures to be taken should a large event occur to the extent that has occurred in the past. In addition, there is also a need to ensure that public awareness and education of the flood risk is maintained and this should form a key part of the ongoing strategy in this area.

In summary, the key conclusions and recommendations identified in this BMP are as follows:

- Trigger levels have been defined for both MU1 and MU2, primarily based on comparison of beach level with the toe levels of defences. In MU3, a trigger level is only defined in relation to the profile of the flood alleviation channel. All trigger levels are set out in **Section 3.3**, and include details of relevant features of the BMP frontage that are equivalent to the stated levels for ease of reference when undertaking visual inspection of the defences.
- The application of trigger level values should not be absolute, and consideration should also be given to sea conditions at the time of the assessment. It is therefore recommended that unless further severe weather is expected, several days (4-5 days) should be allowed for the beach to recover following the storm before remedial actions to recover beach levels are implemented, unless there is the likelihood of catastrophic failure of the hard-defences if such a delay were taken (**Section 3.3**).
- The recommended monitoring programme incorporates the ongoing work of the Plymouth Coastal Observatory (PCO) as part of the South West Regional Coastal Monitoring Programme (SWRCMP), although it is recommended that further beach monitoring data is collected to inform the revision of the BMP in five years' time (**Section 4**).

To aid this, the following should be implemented:

- The monitoring and routine reporting on additional beach parameters, such as beach plan shape, crest level and crest width above given threshold level should also occur (**Section 4.1.1** and **Section 4.6**);
- Occasional surveys of the flood alleviation channel should be undertaken to monitor the channel profile in relation to the design profile (**Section 4.1.1**);

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- Changes to the way in which post-storm surveys are triggered should be explored and mechanisms put in place (**Section 4.1.1**);
 - Consideration to triggering pre-storm surveys could also usefully be undertaken if a forecast storm event is thought likely to result in significant impacts on the beach morphology (**Section 4.1.1**);
 - In order to improve the recording of tide level data at this south-eastern end of Chesil Beach, it is recommended that a hydrodynamic modelling study be carried out to enable parameters to be established for converting recorded levels at West Bay and/or Weymouth Harbour to be related more equivocally to the BMP area (**Section 4.4.1**);
 - Details of the storm conditions (waves, winds and water levels) will need to be recorded in support of the post-storm profile surveys (**Section 4.4.2**); and
- Visual walkover inspections should continue to be undertaken by the Environment Agency and/or Weymouth & Portland Borough Council to monitor beach crest level against the seawall, as well as depth of shingle over the gabions and infilling of the flood alleviation channel with shingle (**Section 4.1.6**).
 - An annual visual inspection of all of the coastal defence structures along the BMP frontage should be undertaken (**Section 4.2.1**).
 - Full structural inspections of the seawalls, gabion castle and mattresses, slope stabilisation measures, interceptor drain, flood gates and culverts are to be carried out every five years (**Section 4.2.2**).
 - Ownership of all assets such as walls at the back of the beach in MU2 is uncertain and so the ownership of these walls should be confirmed in the immediate future such that future maintenance requirements can be planned (**Section 4.2.1**).
 - Recommendations to be implemented when undertaking works on the beach, including:
 - New services and utilities checks should be carried out before any works occur on site (**Section 1.3.7**);
 - The need for other consents/licences depending on the nature of the works is to be discussed and agreed with the relevant consenting bodies in the immediate future (**Section 1.6**). As a minimum, consent is needed from Natural England each time works are carried out in the SSSI area (**Section 1.6.1**);
 - Beach recycling logs are to be maintained whenever beach maintenance works occur. It is recommended that two separate beach surveys, 'in' (pre-recycling) and 'out' (post-recycling), are undertaken for the first few beach recycling campaigns to validate the logs (**Section 4.1.3**);
 - It is recommended that a banksman is present with each machine, and that either spare personnel or a dedicated communications officer, along with signage, are employed to direct public access to safe sections of the promenade and beach during works (**Section 5.4.5**);

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- Information boards should be displayed whilst the works are being carried out to explain what is being done and why (**Section 5.4.5**);
 - The Environment Agency should continue to work with WPBC to ensure that the management of the beach is complementary with the management of the coast protection seawall (**Section 5.2.1**);
 - In order to reduce the impact of plant on the beach sediment (i.e. minimise compaction and/or disturbance of beach sediment), it is recommended that routes used by plant are continually altered and that spragging by plant on the shingle (i.e. turning 'on the spot') is kept to a minimum (**Section 5.4.1**);
 - The Masonic Car Park is to act as the primary compound area and access route for works on the beach face in MU1 and MU2. The final compound extent and access routes should be agreed between the Environment Agency, Weymouth & Portland Borough Council, Natural England and the Jurassic Coast's Earth Science Manager in the immediate future (**Section 5.4.4**);
 - Should a situation arise that requires access to locations in MU3, then the Environment Agency (or others) should use the recommended route onto the beach from the visitor centre car park identified in this BMP. Routes along the beach will depend on the location of any issues to be addressed and will need to be continually altered to reduce impact of plant on the beach sediment. The extent of any compound that may be required within the visitor centre car park will need to be agreed at the time with Natural England and other stakeholders, as would any additional/alternative access route that may be needed from the lay-by adjacent the Portland Harbour Culvert at the north-west end of the flood alleviation channel (**Section 5.4.4**); and
 - Notification of beach works should be explicitly given to key organisations and other stakeholders with interests in the area (**Section 5.4.6**).
- Recommendations relating to emergency planning include:
 - The Environment Agency should continue to work with Dorset County Council (DCC) and WPBC to develop future revisions of the *Chiswell Operational Response Plan* to ensure that the risks identified in this BMP are addressed in the emergency plan (**Section 1.7.10**); and
 - There is a need to ensure public awareness and education of the flood risks is maintained and this should form a key part of the ongoing strategy in this area (**Section 1.4.1.2**).
- Research in the following areas could also be undertaken to aid future management of this area, including:
 - Definition of the definitive master profile to identify more precisely the level of the underlying strata so that more accurate estimates of beach volume can be made (**Section 4.1.2**);
 - Improve understanding of sediment composition and porosity both along and within the beach (**Section 4.1.5**); and

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- Examining the relationship between beach water levels, beach sediment composition, wave (both locally generated and swell) and wind climate and tide conditions (**Section 4.1.9**).

OPERATIONAL TASKS SUMMARY

This operational tasks summary provides a succinct guide to the key information that those undertaking operational tasks along the Chesil Beach (Portland to Small Mouth) Management Plan (BMP) area (see *Figure OS.1*) need to know. This is presented as a series of 12 questions from Q1 to Q12.

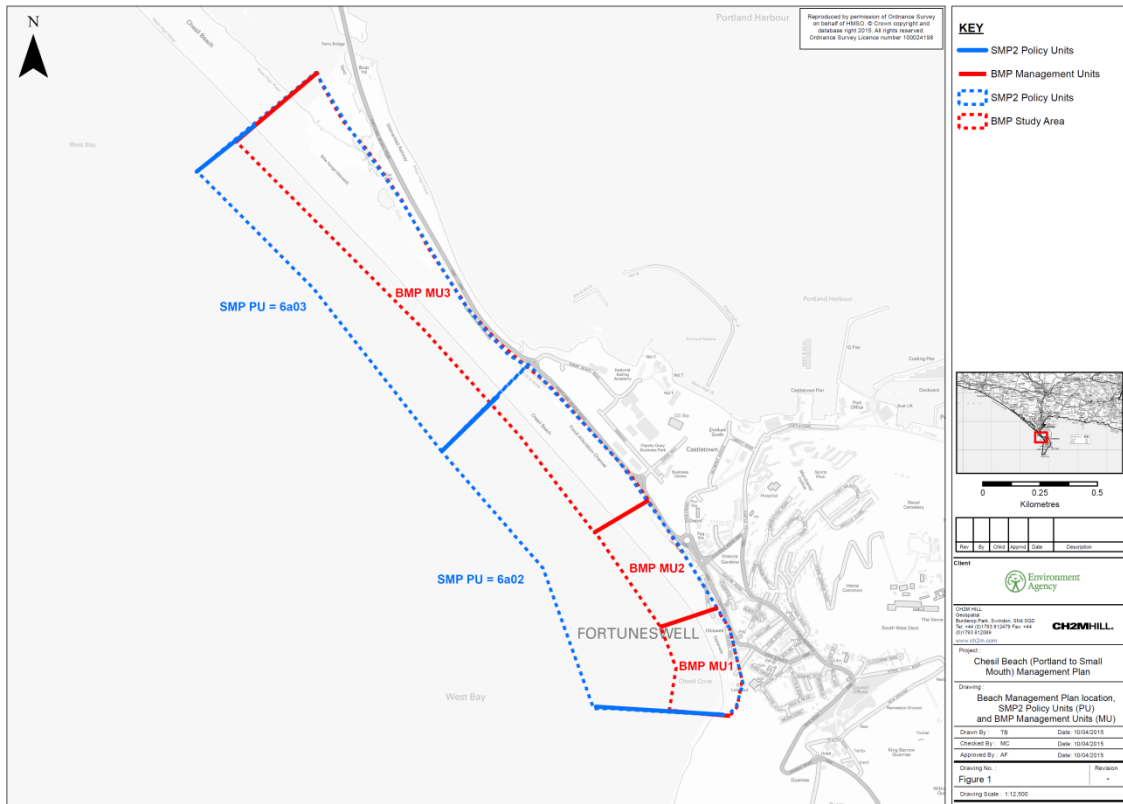


Figure OS.1 BMP extent, including BMP Management Units and SMP2 Policy Units.

Q1. What are the coastal defences along the BMP frontage?

The present coastal defences at Chiswell (See *Figure OS.2*), that all work together to reduce the risk of coastal flooding, coastal erosion and landslides, are comprised of the following elements:

- **Seawalls** – Three distinct concrete seawalls were built between 1958 and 1984 to protect Chiswell. The two south-easternmost sections of seawall are the oldest and are complemented by drainage systems which help stabilise the coastal slopes behind (see *Figure OS.3*). This reduces the risk of landslides along West Weares. They are managed by Weymouth & Portland Borough Council.

The third section of seawall was originally built in the 1960s. In the 1980s this wall was replaced with a new wall built over the top of the 1960s wall, and a curved section was also added to the top of the wall to reduce the amount of water coming over and into Chiswell (see *Figure OS.4*). The lower part of this wall is managed and maintained by Weymouth and Portland Borough Council. The upper wave return wall part (including the flood gates) is owned, maintained and operated by the Environment Agency.

- **Gabion castle and mattress** – Gabion wire baskets filled with beach material provide a transition between the seawall in front of the Cove House Inn and the natural Chesil Beach.

These create the 'castle' structure and a further 550m of mattress layers (thin sloping gabions baskets) on top serve to prevent the crest of the beach being lowered when waves overtop the beach (see **Figures OS.5 and OS.6**). These structures are managed and maintained by the Environment Agency.

- **Interceptor drain** – Running beneath the seawall (from the Cove House Inn) and the gabion mattresses is an interceptor drain. During storm events, large waves push seawater through the shingle beach. This drain prevents that water flowing through the beach and into Chiswell by diverting the water into the flood alleviation channel via 'the Windows' and ultimately into Portland Harbour (see **Figures OS.5 and OS.6**). It is managed and maintained by the Environment Agency. *NB: once the beach is saturated the risk of wave overtopping is greater.*
- **Flood alleviation channel (Monsoon drain)** – The flood alleviation channel is the open channel that runs beside the Portland Beach Road. This carries sea water from the interceptor drain into Portland Harbour via a culvert located beneath the road (see **Figure OS.2**). It is managed and maintained by the Environment Agency.
- **Shingle beach** – This is an important part of the coastal defence system and the beach profile is monitored and managed in order to meet the requirements of this BMP.

Further details about the present coastal defences are provided in **Sections 1.3.3 and 3.1**.

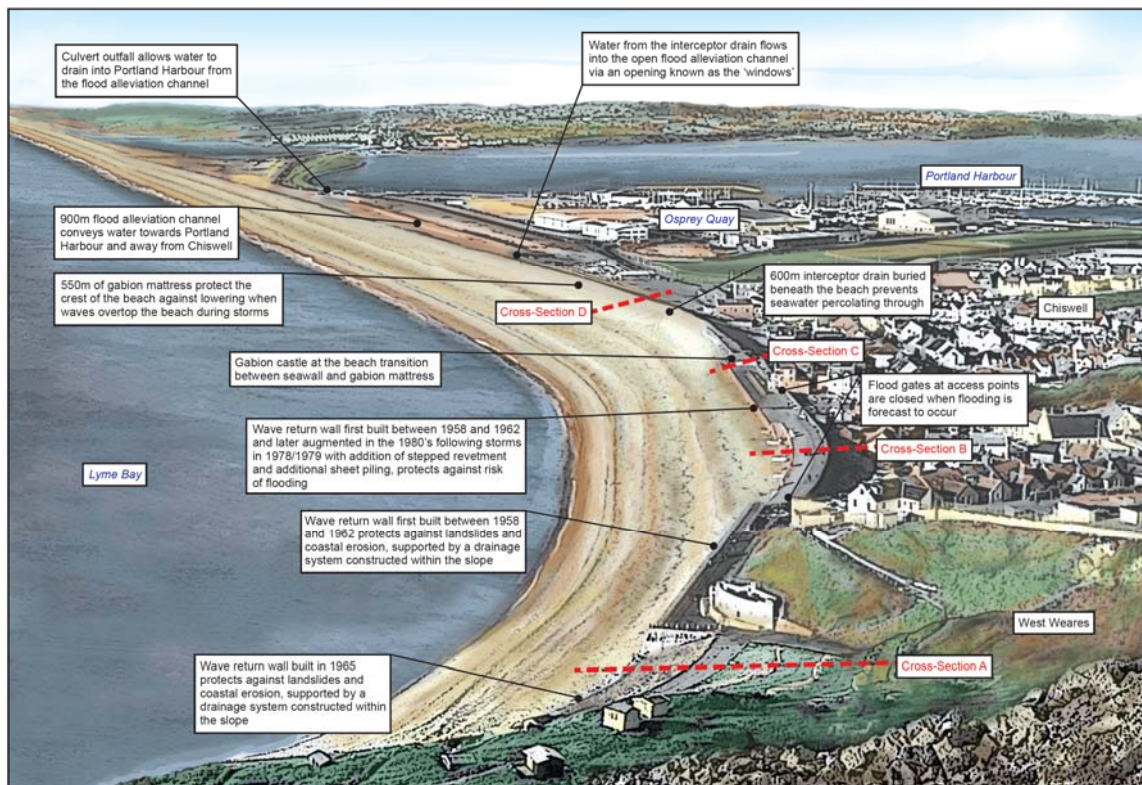


Figure OS.2 Overview of the coastal defence system along the BMP frontage..

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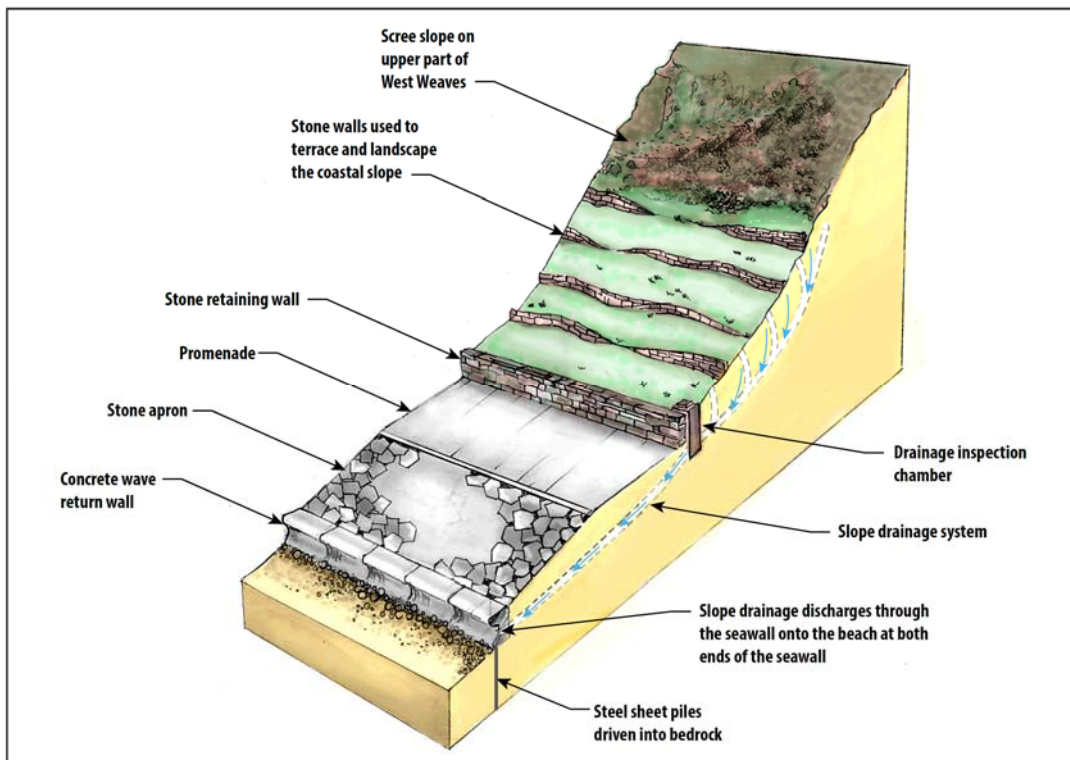


Figure OS.3 Typical section through the seawall and slope stabilisation measures at West Weares in MU1 (along cross-section A with reference to Figure OS.2 above).

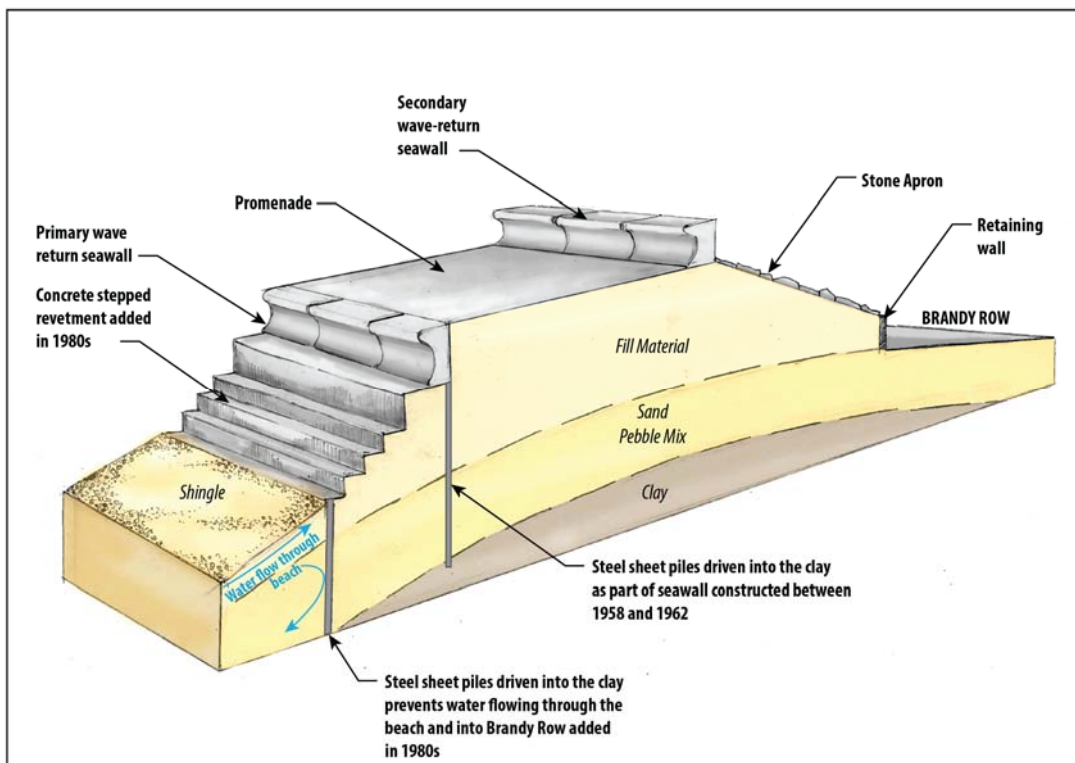


Figure OS.4 Typical section through the seawall in MU1 (along cross-section B with reference to Figure OS.2 above).

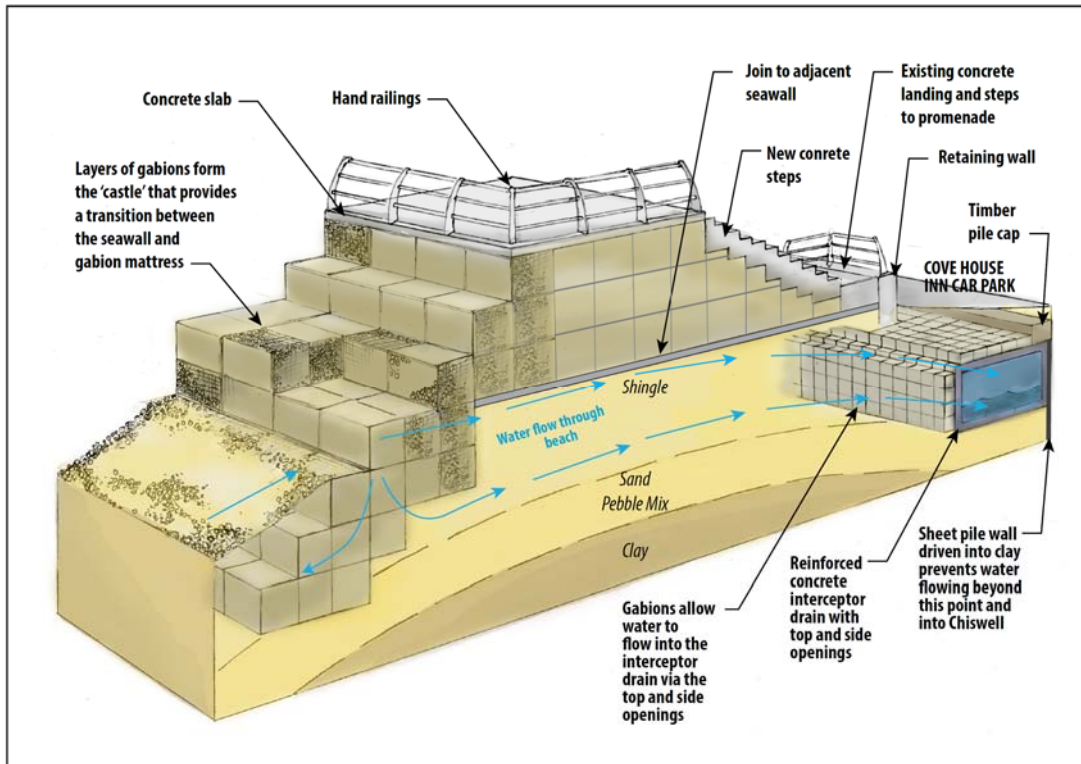


Figure OS.5 Typical section through the gabion castle at the boundary of MU1 and MU2 (along cross-section C with reference to Figure OS.2 above).

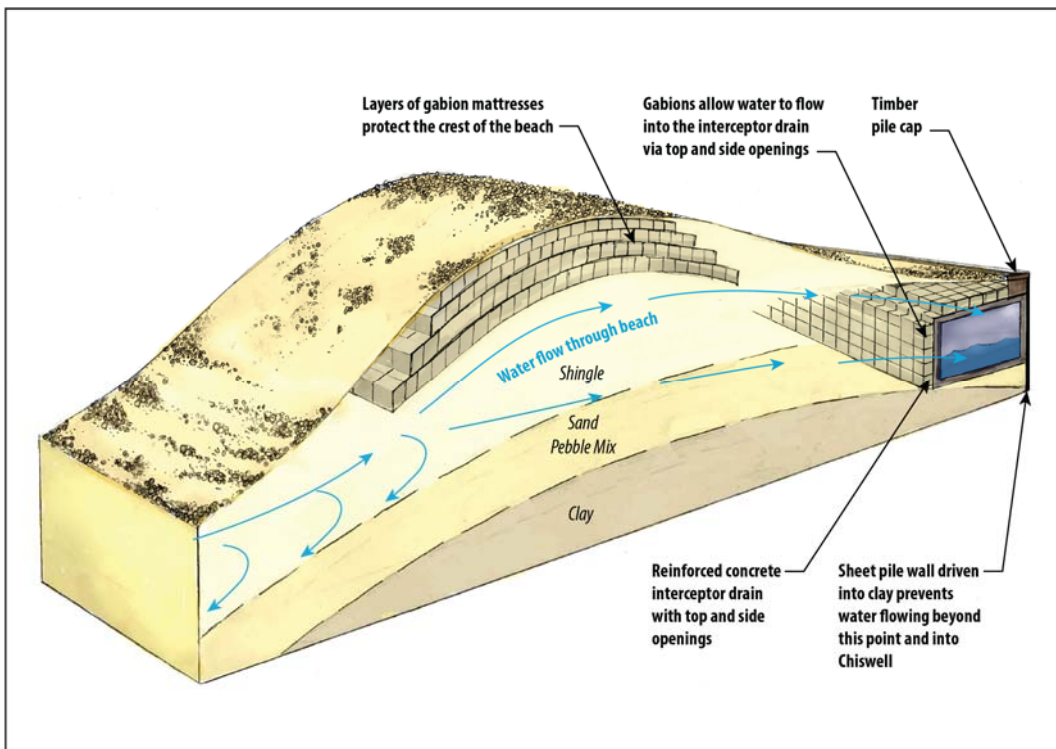


Figure OS.6 Typical section through the gabion mattress crest protection in MU2 (along cross-section D with reference to Figure OS.2 above).

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Q2. What monitoring of coastal processes is done?

Over the next 5 years, a comprehensive monitoring programme is to be undertaken in order to provide a greater level of quantitative field data. Data to be collected includes that which is routinely captured by the Plymouth Coastal Observatory (PCO) as part of the South-West Regional Coastal Monitoring Programme (SWRCMP), who carry out two annual beach profile surveys (and post-storm surveys when needed), a 5-yearly bathymetry survey, have a wave buoy deployed offshore of the BMP area at about the -10mCD bathymetry contour, and undertake aerial LiDAR and aerial photography surveys on a frequent basis. In addition, monitoring of water levels within the beach is undertaken by the Environment Agency via a number of telemetry devices, who also undertake additional beach monitoring surveys and *ad hoc* bathymetric surveys (as required). This survey information is regularly analysed to monitor changes in beach profile and volume.

In terms of post-storm surveys, these are to be triggered by the Environment Agency when an event occurs (or is forecast to occur) whereby the following levels will be met/exceeded:

- Wave period = 12s or greater.
- Significant wave height = 5m or greater.
- Tide levels at Weymouth = 1.8mOD or greater.

Further details on the monitoring regime are contained in **Section 4**.

Q3. What is required of visual inspections?

In addition to monitoring coastal processes, an annual visual inspection of all of the coastal defence structures along the BMP frontage should be undertaken. This should occur during the spring of each year to identify any issues so that subsequent completion of any maintenance works required can be completed prior to the busy summer period, thus avoiding impacting on the amenity use of the beach. Visual inspections to monitor structures after storms should also occur, since damage to the structures is most likely to occur during storms.

The visual inspection should look for a range of parameters as described in **Section 4.2.1**. This includes assessing whether trigger levels defined in **Table OS.1** have occurred.

Table OS.1 Summary of trigger levels

Management Unit	Sub-Section Description	Action Level	Crisis Level
MU1	Section of re-curved wall with stepped revetment fronting it in MU1	approximately +5.1mOD <i>[equivalent to the top of the 5th step of the revetment (counting from the top) being visible; see Figure OS.7]</i>	approximately +4.1mOD
	Section of wall with toe protection added in 2014 fronting it in MU1	approximately +4.1mOD <i>[equivalent to the top of the steel sheet piling of the toe protection being visible; see Figure OS.8]</i>	approximately +3.1mOD

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Management Unit	Sub-Section Description	Action Level	Crisis Level
	WPBC wall at the south-eastern end of MU1	approximately +3.0mOD <i>[equivalent to (a) the point where the top of the steel sheet piling will be visible (West Weares wall) – Figure OS.9 – and/or (b) three full concrete panels being visible from the top of the seawall (below Quiddles café) – Figure OS.10]</i>	approximately +2.0mOD
	All re-curved walls	Beach crest height to be at least 1.5m below wall crest height	-
MU2	The area of the gabion castle	approximately +6.0mOD <i>[equivalent to five gabion baskets being fully exposed below the level of the adjacent seawall/promenade; see Figure OS.11]</i>	approximately +5.0mOD
	Along the length of the gabion mattresses	between +9.0 to +11.0mOD, depending on the specific depth of the gabions along the length of the defence <i>[equivalent to the two top mattress layers and the upper part of the third (bottom) mattress layer being fully exposed; see Figure OS.12]</i>	between +8.0 to +10.0mOD, depending on the specific depth of the gabions along the length of the defence
	Along the length of the gabion mattresses	Depth of shingle over the gabions falls to less than 300mm (or the gabion mattresses become exposed at any point).	-
MU3	Flood Alleviation Channel (Monsoon Drain)	Infilling of channel with shingle pushed in by percolation events (that form ‘canns’) reduces channel capacity from design profile; see Figure OS.13 .	-

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Figure OS.7 Part of the stepped revetment with all five steps showing (taken 9th February 2014, courtesy of A. Frampton).



Figure OS.8 The new 2014 toe protection structure in MU1 with top of steel sheet piling visible (taken 29th August 2014, courtesy of A. Frampton).



Figure OS.9 Top of the steel sheet piling along the West Weares wall (taken 29th August 2014, courtesy A. Frampton).



Figure OS.10 Concrete panels below the wall crest along the part of the wall below Quiddles café (taken 29th August 2014, courtesy A. Frampton).



Figure OS.11 View of the gabion castle with one and a half gabion baskets exposed below the level of the adjacent wall/promenade (taken 29th August 2014, courtesy A. Frampton).

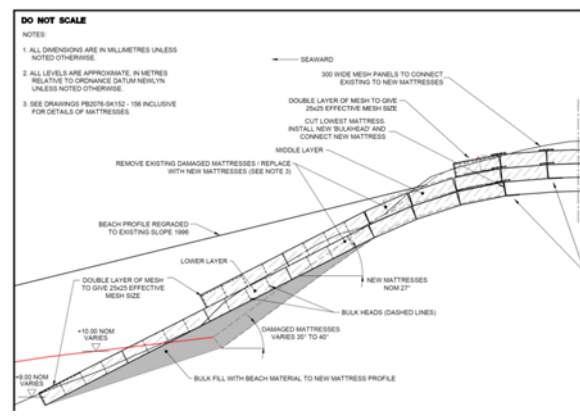


Figure OS.12 Part of drawing showing mattress layers re-built in 2014 (from Appendix I.4).

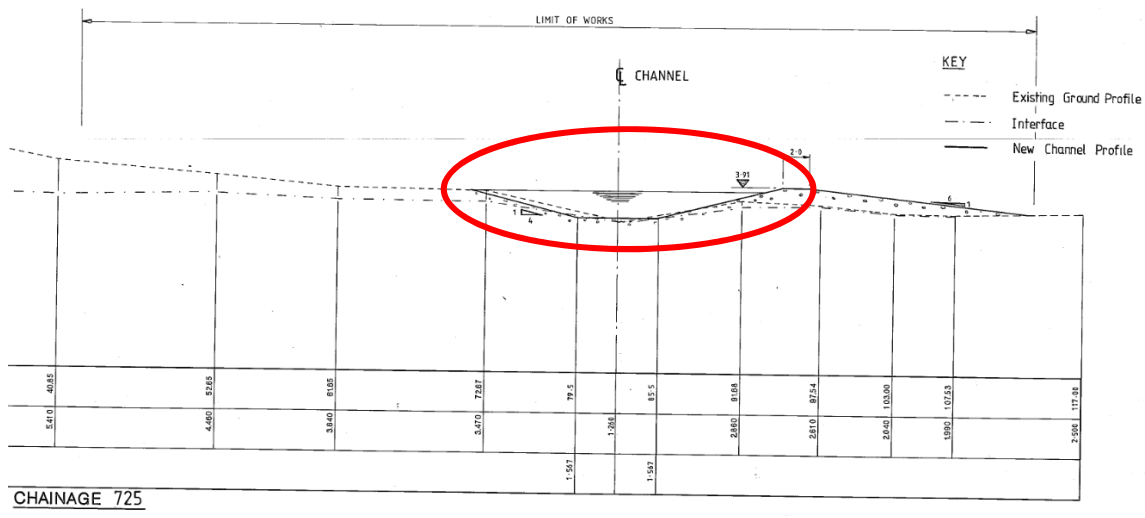


Figure OS.13 Typical cross-section of the channel between 'The Windows' and the 'Portland Harbour Culvert' (refer to Appendix I.2 for further details).

NB: The application of trigger level values should not be absolute, and consideration should also be given to sea conditions at the time of the assessment. The best opportunity for beach inspections is immediately following a storm event. However, whilst the beach usually experiences significant draw-down and even crest width reduction during storms, the lower part of the beach usually recovers to near its pre-storm level shortly afterwards in calmer conditions (but the upper part of the beach towards the crest can take much longer to recover).

It is therefore recommended that unless further severe weather is expected, several days (4-5 days) should be allowed for the beach to recover following the storm before remedial actions to recover beach levels are implemented, unless there is the likelihood of catastrophic failure of the hard-defences if such a delay were taken. In taking this approach of waiting several days, it is important to recognise that it is likely that only recovery of the lower part of the beach will be observed (if any) in this short time-frame; the upper part of the beach is likely to remain at reduced levels for a considerable period of time following the storm event. This is based upon experience following the winter 2013/14 storms.

Further details on the trigger levels are provided in **Section 3.3**.

Q4. What should be done by way of routine maintenance?

At present no regular beach maintenance works occur, but rather on a basis informed by a combination of visual inspection and beach monitoring surveys. This is to continue in the period to the next BMP review (in 5 years). As such, the undertaking of beach maintenance works is to be informed by the analysis of the results of the beach monitoring and the beach profile surveys undertaken in the spring and autumn of each year and following storm events, along with visual inspections. The works that would occur as a result of these inspections would primarily be in MU1 and MU2 and are expected to involve the types of works described in **Section 5.1.1**. Works in MU3 are only likely if there is significant crest lowering or breaching (refer to Q6 and Q7).

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Routine maintenance works to the various coastal defence elements along the BMP frontage will also be guided by ongoing inspection; this includes inspection of the seawalls, flood gates, confined space inspection of the interceptor culvert and slope drainage chambers, and testing of the flood warning sirens. When either routine inspection or rapid assessment following a storm event identifies a defect in the defence, be it a crack in the defence or damage to public safety aspects of the defence (e.g. buckled hand railings or trip hazards etc.) then the following steps are to be followed:

1. Increased defect monitoring
2. Remedial works.

Further details are provided in **Section 5.1.2**.

Q5. What should be done if Action Levels are reached?

Should the beach level against the seawall crest height in MU1 be too high, as defined by the Action Level (refer to **Table OS.1**) then shingle should be moved from the upper part of the beach and spread over the rest of the profile in the middle to lower part of the beach. If this accumulation of shingle in the upper part of the beach coincides with low beach levels in relation to the toe of the defence in other parts of the beach (i.e. within MU1 or MU2) then shingle should preferentially be placed in those areas and not spread over the beach as described above. Shingle should not be placed at the far south-eastern end of the WPBC wall in MU1.

The other Action Level in MU1 and MU2 relates the beach level to the toe level of the defences (refer to **Table OS.1**). Should the beach level fall to the Action Level for each structure along MU1 or MU2, then the response should be to increase the frequency of survey and visual inspection to more closely monitor the situation and determine if there is a continuing trend of beach lowering in relation to trigger levels (and so identify if/when Crisis Level is reached), or if it is a temporary natural change.

In MU3, if monitoring finds that the flood alleviation channel or culverts is infilled then the procedures set out in **Section 5.1.1** should be followed

With regards to the coastal defence structure no action level works are defined. Works will be reactive and so will follow the on-going works procedures defined in **Section 5.1.2**.

Further details on Action Level responses are provided in **Section 5.2**.

Q6. What should be done if Crisis Levels are reached?

If a **Crisis Level** (refer to **Table OS.1**) is identified as being reached on a profile, the immediate task would be to carry out a visual inspection of the profile concerned; firstly to validate the survey data and that it is representative of the general beach area around that location (i.e. not a localised 'low' point). If the **Crisis Level** is shown to be a general problem to be addressed, then timely action will be required to safeguard the integrity of the seawall and gabions.

The measures that should be considered once Crisis Levels are reached are recycling and re-profiling of sediment from other parts of the beach within MU1 and MU2 so long as to do so does not compromise the beach level in relation to the structures in those areas. The location from where to

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retrieve shingle for this purpose should be guided by a combination of beach profile survey (either routine or post-storm – refer to **Section 4.1.1**) and visual inspection.

The normal storm response of a beach involves the flattening of the front (seaward) slope as material is removed from the upper part of the beach and distributed further seaward along the profile (although some material may move alongshore also). As such, it is likely that material to be recycled in response to this Crisis Level will come from lower down the beach profile. If beach recycling is to occur in response to a Crisis Level being reached, then an informed discussion may be required between Environment Agency staff and officers of Weymouth & Portland Borough Council as to whether the priority area for placement of material should be along the toe of the gabion castle and mattresses in MU2 or the toe of the seawall in MU1. Movement of beach shingle to the south-easternmost end of MU1 should be avoided for the reasons stated in **Section 5.2.1**. When placing material, a terraced profile such as that illustrated in **Figure OS.14** be adopted as experience from the winter 2013/14 emergency response works suggests this provides a more stable beach shape and so protection, particularly to the gabions in MU2. This terracing will eventually be re-shaped by natural processes over a period of days to months, particularly on the lower part of the beach slope.

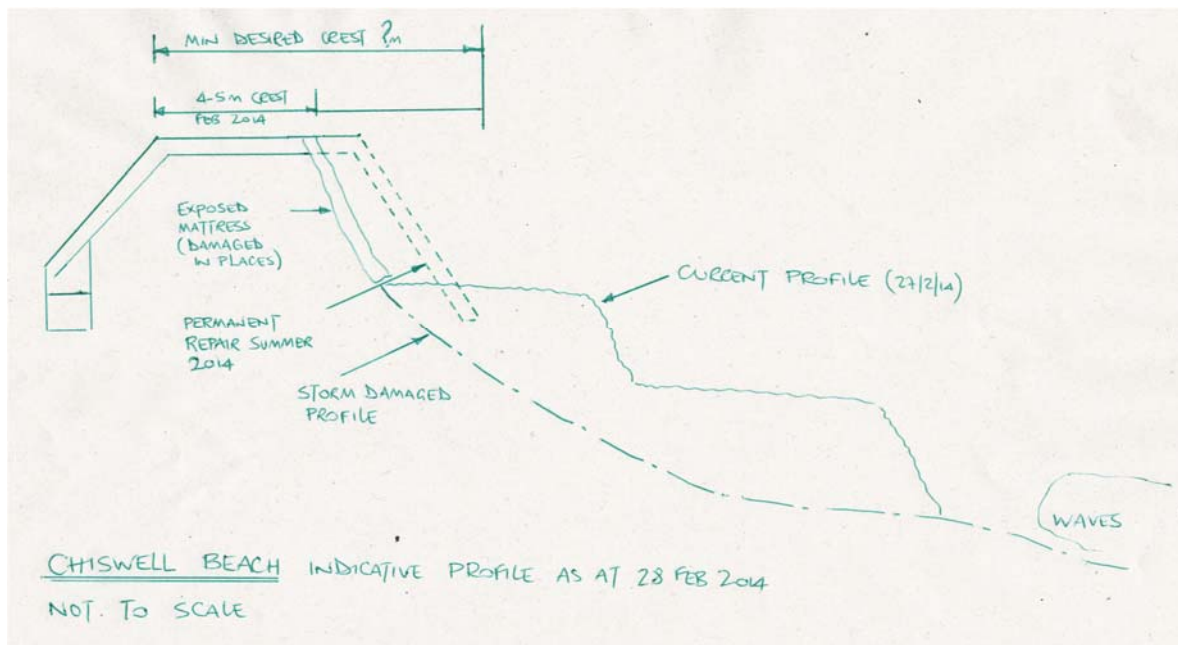


Figure OS.14 Illustration of profile terracing to be adopted during Crisis Level works (illustration developed during winter 2013/14 emergency response works).

Crisis Level works within MU3 would be required only if there was significant crest lowering and/or a breach in the shingle beach. In such a case, the crest level should be restored to pre-storm level where possible, likely in a more landward position – see also Q7.

Further details on Crisis Level responses are provided in **Section 5.3**.

These Crisis Level works should also be undertaken alongside the procedures set out in the emergency plan for Chiswell (refer to **Section 1.7.12**).

Q7. What should be done if a breach occurs?

Should a large wave event occur that causes significant crest lowering resulting in overtopping, overwashing or even breaching of Chesil Beach, particularly in the north-western part of the BMP area in MU3, then rapid inundation could occur, flooding Chiswell and affecting road access via the A354 Portland Beach Road.

In response to such an event, use of excavators, dump trucks and bulldozers is likely to be required to move material that has been pushed over the beach crest (and deposited as overwash deposits) back up the beach backslope in order to restore the defence function of the beach. This activity will seek to restore the 'typical' pre-event barrier beach profile. It would be likely that the profile would be restored in a more landwards position in MU3, reflecting the fact that a large amount of material is likely to have moved eastwards during such an event and it will be easier to rebuild the profile where the bulk of the material resides rather than moving it all back seawards. However, the practicality of this will depend upon the extent of impact on property and infrastructure and a decision will need to be made by those on site post-event about exactly where material needs to be placed to restore the profile.

A breach within the gabion mattresses (MU2) or the south-eastern end of MU3 would need to be repaired in an appropriate alignment with the existing defences in order to maintain the future integrity of the coastal defence scheme. However, if the result of a large event does not pose a risk to infrastructure or property, it may be more practical to not intervene at all but simply allow the beach to recover naturally in a more eastwards position. This approach may be most appropriate towards the north-western end of MU3 where the beach is backed by the Fleet. In this instance, advice should be sought from Natural England and other relevant parties.

Further details are provided in **Section 5.3**.

Q8. What are the implementation requirements when undertaking works (either routine or in response to trigger levels being reached)?

Beach recycling and re-profiling, as well as maintenance work to the coastal defence structures, will typically be carried out using a tracked bulldozer and a hydraulic excavator, although other plant may be used as appropriate such as dump trucks and/or other specialized plant (e.g. piling rigs). Rubber tracked plant are not available in the plant size required for viable works along the BMP area, therefore regular tracked plant, suitably sized for the work, will be appropriate when undertaking works. This will typically be excavators (or similar) and D8 bulldozers (or similar) up to 40T (this being the weight limit allowed for crossing the culvert). In order to reduce the impact of plant on the beach sediment (i.e. minimise compaction and/or disturbance of beach sediment), it is recommended that routes used by plant are continually altered and that spragging by plant on the shingle (i.e. turning 'on the spot') is kept to a minimum.

Plant access to the beach in MU1 and MU2 will continue to be via the Masonic Car Park (refer to **Figure OS.15**). To support this, a compound is to be used in the Masonic Car Park. **Figure OS.16** shows proposed compound extents and preferred access routes over the beach (taking account of utilities beneath the beach – refer to **Section 5.1.1**).

- The compound should be located at Site 1 (refer to **Figure OS.16**) in the Masonic car park if the gabions are intact and allow access over them; otherwise access to the beach would be via

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an alternative site by the windows (Site 2 on **Figure OS.16**). If access is over the front face of the gabion mattresses in MU2, then the angle of the slope should be sufficiently shallow as to allow safe passage. Should Site 2 be used at first, once access allows, the site compound could be relocated back from Site 2 to Site 1 in the main car park for the duration of any remaining works.

- When accessing over the beach with plant, the route used should be regularly altered to prevent compaction and/or disturbance of material along a single track route. The exception to this is the initial access route onto and over the beach crest, as this must be carefully constructed and maintained throughout the works.

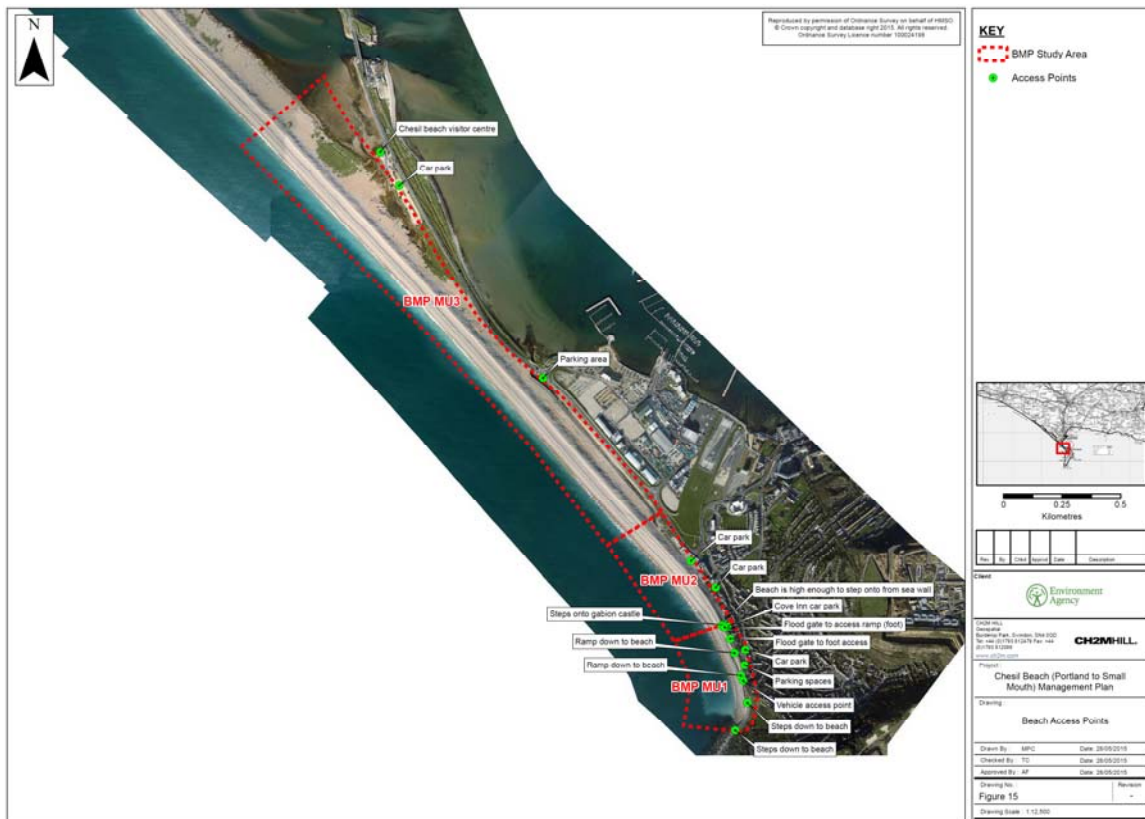


Figure OS.15 Beach access points.

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Figure OS.16 Proposed compound extents in the Masonic Car Park and access routes over the beach.

Should it be necessary for the Environment Agency Operations Delivery Team to be supported by the military in future recovery works (as occurred in response to the winter 2013/14 storms), then suitably sized plant (within the limits stated above) and competent operators would be required, using the same site access requirements described above.

Further details on implementation requirements, including public safety management and notification of works is provided in **Section 5.4**.

Q9. What are the environmental constraints/requirements when works (either routine or in response to trigger levels being reached)?

The BMP area is within 2km of numerous environmentally designated areas including UNESCO World Heritage Site, Special Area of Conservation (SAC), Special Protection Area (SPA), Ramsar, Site of Special Scientific Interest, Marine Conservation Zone and Area of Outstanding Natural Beauty. There are also a range of historic environment features and assets within and around the BMP area, including Scheduled Monuments, Listed Buildings and shipwrecks (refer to **Section 2.8**). As such works along the BMP frontage needs to consider the (potential) impacts upon these various features, as described in **Section 1.4.2**. This will include monitoring of the environmental features of interest that are primarily located in MU3:

- Monitor the distribution and composition of perennial vegetation of stony banks (annual vegetated drift lines, perennial vegetation of stony banks, Mediterranean and thermo-Atlantic halophilous scrub);
- Pre and post-storm visual inspection of environmental features; and

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- Pre and post-works (planned or post-storm) inspection of environmental features, especially in the vicinity of plant compounds such as that in the Masonic Car Park.

Further detail is provided in **Section 4.3**.

In order to undertake any future FCERM activities along the BMP frontage such as beach recycling/re-profiling, repairs to coastal defences, or any associated detailed site investigations as may be required, a range of licences, approvals and consents may be required, including:

- Marine Licence under the Marine and Coastal Access Act 2009.
- SSSI consent from Natural England.
- Planning Application under the Town and Country Planning Act 1990.
- Crown Estate licence for maintaining boreholes within the beach.

Further detail is provided in Section 1.6.

NOTE: these various designations mean that no new import of beach sediment is expected to occur (i.e. beach recharge), hence the beach management focus on recycling and re-profiling and maintenance of existing coastal defence structures.

Q10. What happens when a storm or flood event is forecast and/or occurs?

The Environment Agency receives regular forecast of wind, wave and tide (surge) for the BMP area. These are assessed against defined criteria to determine if a Flood Alert, Flood Warning or Severe Flood Warning should be issued for the community of Chiswell, or if the A354 Portland Beach Road should be closed to traffic. Further details are provided in **Section 4.5**.

The same forecast criteria may also be used to trigger pre-storm beach profile surveys, should forecast conditions meet the criteria defined for post-storm beach profile surveys (described above and in **Section 4.1.1**).

Q11. What needs to happen following a storm or flood event?

Following a storm event, visual inspection is to occur as described above and in **Section 4**. This will lead on to appropriate responses, as described above.

Should there be a requirement to undertake any beach works, the Environment Agency field team should be mobilised and, if necessary, assistance from either the military and/or an appropriate contractor (employed via emergency provisions of the Environment Agency's supplier framework; in 2014, TVO (Team Van Oord) was employed for this purpose via the WEM Framework).

In addition, details of the storm event need to be recorded in an event log including:

- Post-storm beach profiles;
- Wave, wind, tide and borehole telemetry data;
- Details of damage to coastal defence structures; and
- Details of if/where/when flooding occurred at Chiswell, and to what extent and what was impacts (e.g. properties flooded; roads closed etc).

Section 4.4 provides further details on these requirements.

Q12. What are the current uncertainties around coastal flood and erosion risk management relating to the BMP area?

Overall, the broad-scale processes that affect Chesil Beach are not very well understood, with much uncertainty about forcing and response mechanisms that need to be resolved in order to improve future management decisions. Chesil Beach is a unique and extreme landform in terms of its scale, morphology and sedimentology and so perhaps it should be no surprise that it is very difficult to model and predict its behaviour using available methods. The uncertainty in this area is also due to there being limited quantitative data being available especially for very infrequent extreme events. This means it is difficult to predict future evolution or the SoP offered along this frontage in a way that can provide robust evidence-based mechanisms for guiding future maintenance works (refer to **Section 1.4.4**).

This uncertainty about the natural processes in turn leads onto key uncertainties with regards managing coastal flood and erosion risk along the BMP frontage, as follows:

- How Standard of Protection (SoP) is defined. Current methods are based on wave overtopping thresholds that only relate to MU1 and do not allow consideration of crest lowering and breach risk. Also, previous assessment suggest the SoP is low, but the defences withstood events in the winter 2013/14 storms well in excess of what those previous assessments concluded they should do (refer to **Section 1.4.1.1**).
- Relationships between physical conditions (i.e. wave height, wave period, tide/surge level, wind, water level within the beach and beach condition) and associated flood risk are not well understood. This means there is a risk that flood warning procedures may not predict a large event to be able to provide adequate warning time to evacuate flood risk areas (refer to **Section 1.4.1.2**).

The BMP includes actions for further study and research to help improve understanding and reduce these uncertainties (refer to **Section 6 and Appendix F**).

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1 INTRODUCTION

1.1 Background

Chesil Beach is an iconic feature of the Dorset Coast and the UNESCO Dorset and East Devon World Heritage Coast (the 'Jurassic Coast'), being designated for its unique geological and geomorphological features. Chesil Beach is a linear, swash-aligned, shingle barrier beach that extends from Portland in the east to West Bay harbour in the west. The area of interest for this Beach Management Plan (BMP), which provides the first review and update of the BMP for this area published in November 2010, is at the south-eastern end of Chesil Beach from Chiswell at Portland to opposite Small Mouth (refer to **Figure 1.1**).

Throughout the BMP, recommendations are identified with **bold underlined text**. These are also summarised in the Action Plan contained in **Section 6**.

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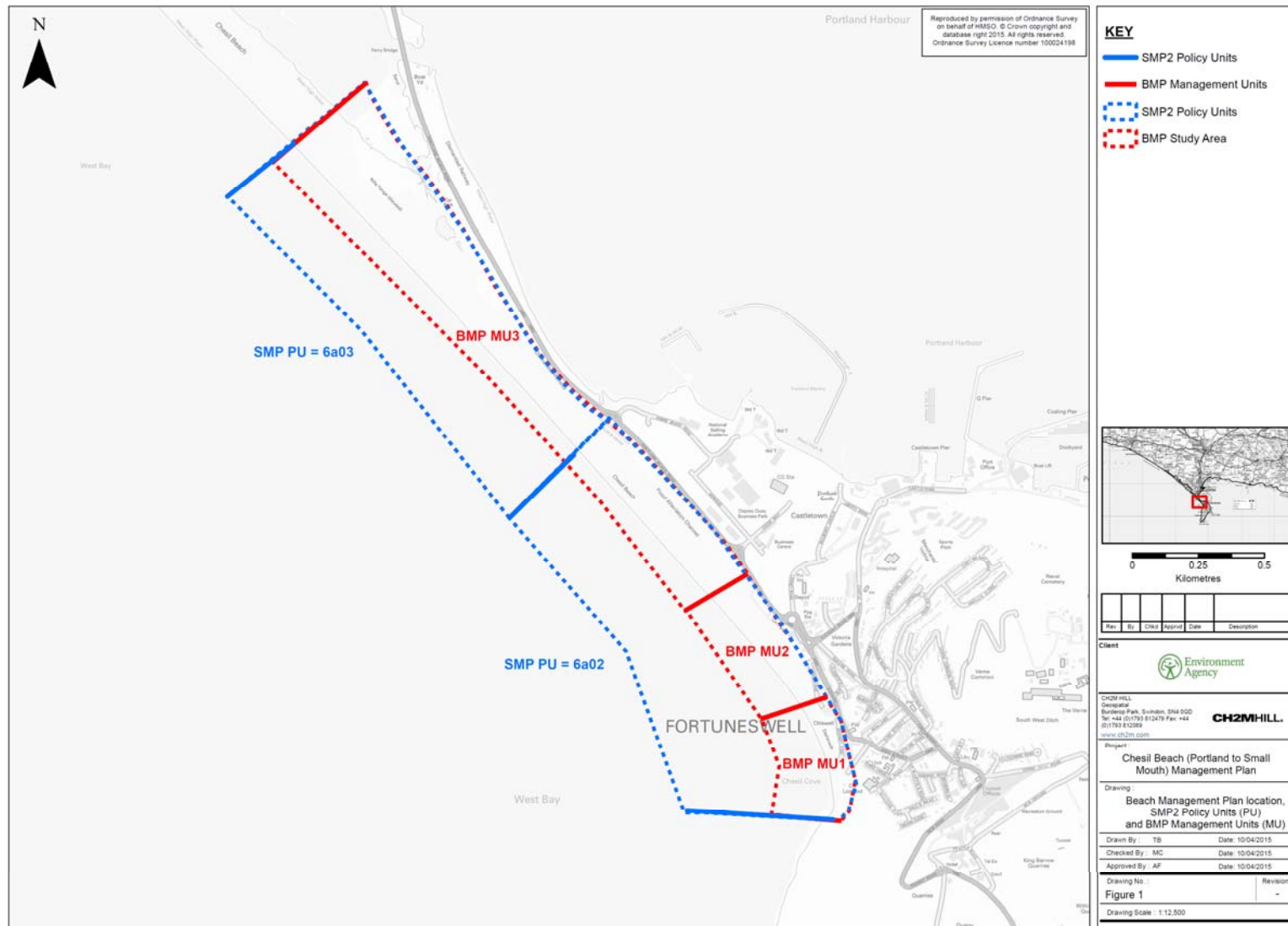


Figure 1.1 *BMP extent, including BMP Management Units and SMP2 Policy Units.*

The area behind Chesil Beach comprises low-lying extensively developed land at Chiswell that is at risk of flooding from the Chesil Beach frontage. Many flood events have occurred here in the past (see **Figures 1.2 and 1.3** and **Section 1.3.2**) and a capital scheme was constructed in the mid-1980's to reduce flood risk following two successive flood events in late 1978 and early 1979. This scheme involved the construction of a new seawall and promenade; a gabion castle and mattress to stabilise the beach crest; and an interceptor drain within the beach with a flood alleviation channel to divert water coming through the beach into Portland Harbour to the east of the beach. Part of the seawall was repaired following breach as a result of storms over the winter of 2013/14 (see **Figures 1.4a and 1.4b**), whilst the gabion castle and the first 80m or so of gabion mattress protection were also rebuilt in full in mid-2014 following extensive damage caused by the same winter 2013/14 storms (see **Figures 1.5a and 1.5b**).



Figure 1.2 Impact of flooding at Chiswell in the late 1970's (from Environment Agency photo archive).



Figure 1.3 Impact of flooding at Chiswell on 5th February 2014 (from Environment Agency photo archive).



Figure 1.4a Damage and undermining to part of the seawall in MU1 following 14th February 2014 storm (courtesy of A. Frampton).



Figure 1.4b New seawall toe protection structure constructed to repair damaged and undermined part of seawall on 29th August 2014 (courtesy of A. Frampton).



Figure 1.5a Damage to the gabion castle and mattress in MU2 following the 5th February 2014 storm (courtesy of A. Frampton).



Figure 1.5b Repaired gabions castle on 29th August 2014 (courtesy of A. Frampton).

The interaction between these hard defence structures and the beach is vital to providing protection against the risk of both coastal flooding and erosion/landsliding and this forms a key consideration within the BMP.

The north-western part of the BMP area towards Small Mouth is comprised of undefended naturally functioning beach behind which lies the only access route to the Isle of Portland – the A354 Portland Beach Road. Should the beach in this area roll back or even breach in the future, it could impact upon this key transport route. This is another consideration within this BMP.

Currently the defences along this frontage protect approximately 160 residential and commercial properties at Chiswell with a capital value of around £16 million over a 100 year planning horizon (Halcrow, 2011), taking into account current sea level rise projections. This value does not include the economic value of the A354 road and other assets such as Portland Port and recent development in the Osprey Quay area, which could be affected by a breach of Chesil Beach, to the detriment of the economy of the wider area. Considerations such as these were included in the economic assessment for the scheme in the 1980's (Middlesex Polytechnic Flood Hazard Research Centre, 1980) and when these values are included and inflated to present day, the economic benefits of continuing to provide protection against flood risk are likely to be closer to £50 million.

Clearly this economic case is based on analysis that is several years old and does not reflect fully the economic case for continued Flood and Coastal Erosion Risk Management (FCERM) activities at Chiswell. Therefore, **an updated assessment of the economic case for continued FCERM activities should be considered** to derive updated estimate of benefits (reflecting recent developments and price changes) as well as actual costs spent to date maintaining the defences and a projection of future maintenance costs. A calculation of partnership funding levels should also be undertaken to determine if efforts are needed to seek additional funding sources in the future.

To undertake this economics review, which should be reported in a future Appendix to this BMP, **a full review (and possible rationalisation) of all Chiswell flood modelling and mapping completed to date should be undertaken** to ensure that the uncertainties and limitations of each modelling study are well understood in order that the Environment Agency can ensure that the 'best available' information is used for flood risk mapping and warning at Chiswell in the future, as well as

informing any updated economic assessment. This review should also consider (a) how well (or not) the flood modelling work that has been undertaken assesses the relationship between flow rates/water levels passing through 'The Windows' into the Monsoon Channel and corresponding flood risk to guide revisions of flood warning criteria based on 'The Windows' telemetry data; and (b) potential limitations of previous flood modelling work where no allowance has been made for highway drainage infrastructure beneath the A354 Portland Beach Road.

Historically, Chesil Beach has been subject to extraction of its shingle and pebbles for building and other commercial uses. Selective picking of larger, more spherical, pebbles was conducted at Chesil Cove involving removal of 9,400 tonnes between 1944 and 1972 and was discontinued in 1973 after a public inquiry (Bray *et al*, 2004). At least 50,000 tonnes of gravel were extracted between 1905 and 1907 for the foundations of the oil tank depot at Portland Naval Base. This extraction would have depleted the beach of the larger sized pebbles found at these locations and could have affected beach stability. Taking into account other larger sites of extraction at West Bay and Cogden Beach, it has been estimated that 1.1 million tonnes of gravel in total was extracted from Chesil Beach between the mid-1930s and 1977. Given an estimated beach volume of between 25 and 100 million tonnes, this is equivalent to removal of between 1.1% and 4.4% of the total beach (Carr, 1980).

1.2 Objectives

The BMP covers areas under the responsibility of the Environment Agency, Weymouth & Portland Borough Council (WPBC), who are the coast protection authority, and Plymouth Coastal Observatory (PCO) who undertake monitoring of the coast as part of the South West Regional Coastal Monitoring Programme (SWRCMP).

The aim of the BMP, which has been developed utilising the best practice contained in the CIRIA Beach Management Manual (second edition) (CIRIA, 2010), is to inform, guide and assist these responsible authorities and organisations in managing the beach, hard defence structures and associated slope stabilisation measures, and to ensure that the management of these assets continues to manage the risk of coastal flooding and erosion identified in **Figure 1.6**, whilst recognising and managing the implications for the many environmental designations of the site.

The key objective of this BMP is to manage the risk of coastal flooding, erosion and landsliding by ensuring that an adequate beach is maintained along the south-eastern end of the BMP area towards Chiswell and that the various hard-defence structures are maintained in good order, such that the Standard of Protection (SoP) of the scheme is retained and the risks are minimised. To aid this, the BMP area has been divided into three Management Units (MUs), and this key objective primarily relates to MUs 1 and 2 (refer to **Figure 1.1**). MU1 is the south-eastern most area of the beach backed by seawalls. MU2 is the area of the beach where gabion defences are present. MU3 is the undefended beach extending from Chiswell to Small Mouth.

The hard defence structures are the interceptor drain (comprised of a sheet-piled culvert beneath the gabion structures along MU2 discharging into an open channel via 'The Windows' to flow into Portland Harbour), the gabion castle, the gabion mattresses and the seawalls operated by the Environment Agency and WPBC. The WPBC seawall at the south-easternmost end of MU1 protects a slope stabilisation scheme within the West Weares landslip complex that rises above this part of the frontage, with the drainage from the slope stabilisation discharging to the sea via outlets located at either end of this section of seawall.

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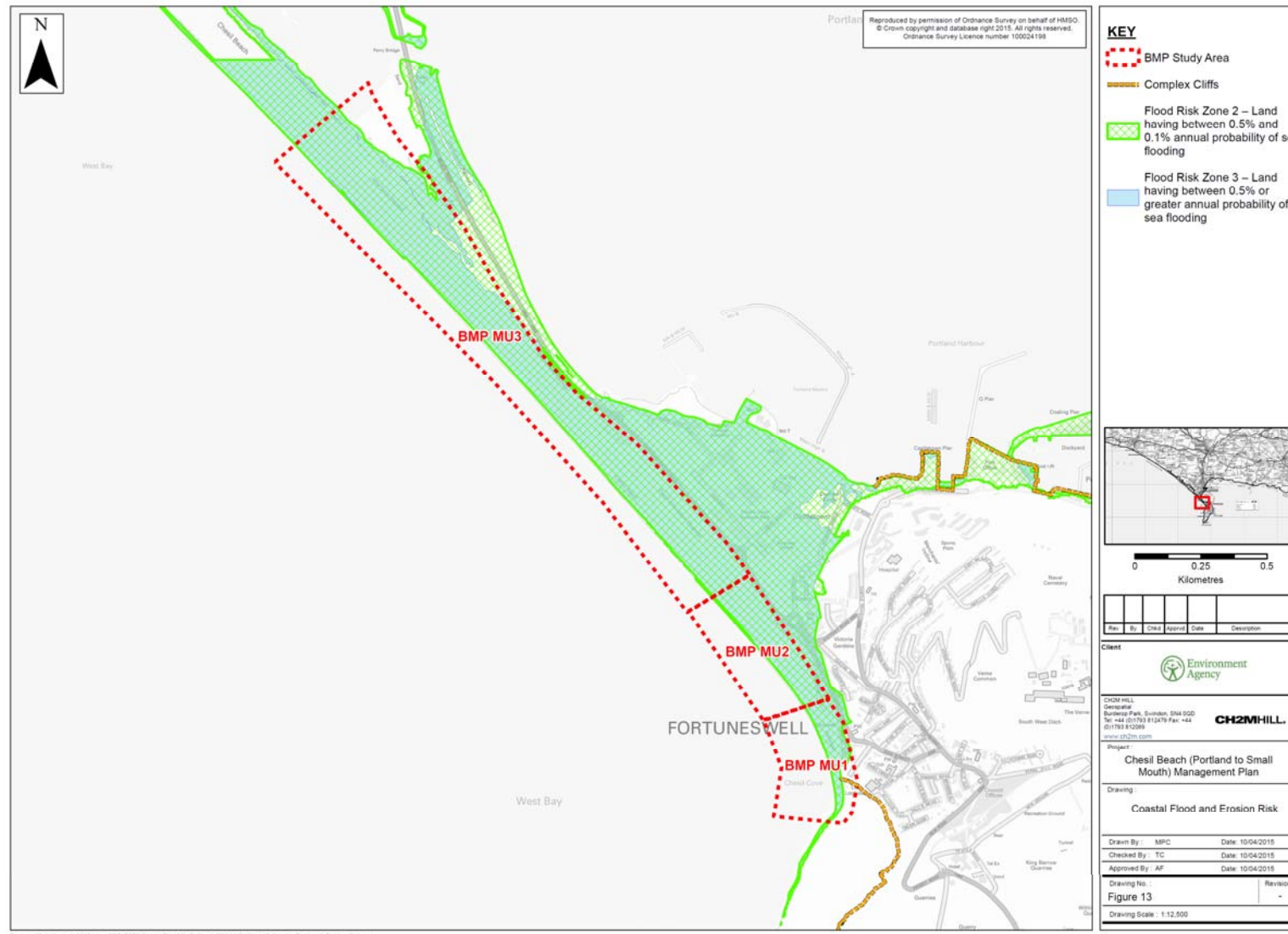


Figure 1.6 Flood and erosion risk areas.

The current SoP for coastal flood risk has previously been stated as being in the range at 6.7% to 10% annual probability of occurrence (APO) (1 in 10 to 1 in 15 year return period) against both overtopping and breaching (Environment Agency, 2009a). However, there is much uncertainty about the definition of SoP for the coastal defences in the BMP area (refer to **Section 1.4.1**) and so the BMP objective is to ensure that the integrity of the defences is maintained such that they are able to perform in a similar way as they did during the sequence of extreme storm events experienced during the winter of 2013/14. To achieve this objective, the BMP sets out the strategy for monitoring and intervention to maintain the beach, hard defence structures and slope stabilisation measures to ensure the coastal defence system continues to provide protection against the risk of coastal flooding, erosion and landsliding at Chiswell. It also includes consideration of the likely options available for carrying out Crisis Level Works should Chesil Beach be overtopped, overwashed or even breached during a large wave event and threaten the A354 Portland Beach Road.

The monitoring and maintenance regime set out in this updated BMP has been subject to a Habitats Regulations Assessment in line with the requirements of the Conservation of Habitats and Species Regulations (2010). This assessment is provided in **Appendix A** and should be updated alongside any future updates of this BMP.

This monitoring and intervention strategy has been developed in the context of selecting an economically, environmentally, socially and technically sustainable management approach for the next 5 years (the BMP review period) and aligned to the Shoreline Management Plan policies for this frontage that are set for a 100 year planning horizon (refer to **Section 1.7.1**). **This BMP is to be reviewed after 5 years.**

The BMP also recommends what further studies may be appropriate to aid future coastal flood and erosion risk management in this area.

As noted on page 1 of this BMP, recommendations are contained throughout the BMP, and are identified with **bold underlined text**. These are also summarised in an Action Plan presented in **Section 6**.

1.3 Location

1.3.1 Environmental Setting

The BMP area is within the following environmentally designated areas:

- Chesil and the Fleet Special Area of Conservation (SAC);
- Isle of Portland to Studland Cliffs SAC;
- Chesil Beach and the Fleet Special Protection Area (SPA);
- Chesil Beach and the Fleet Ramsar Site;
- Dorset and East Devon Coast UNESCO World Heritage Site (the 'Jurassic Coast');
- Chesil and the Fleet Site of Special Scientific Interest (SSSI);
- Chesil Beach and Stennis Ledges Marine Conservation Zone (MCZ);
- Isle of Portland National Character Area (NCA);
- Chesil Beach and the Fleet Nature Reserve; and

- Purbeck and West Dorset Heritage Coast.

In addition, the following environmental designations are within 2km of the BMP area:

- Portland Harbour Shore SSSI;
- Isle of Portland SSSI;
- South of Portland recommended MCZ;
- Dorset Area of Outstanding Natural Beauty (AONB);
- Weymouth Lowlands NCA;
- Designated Bass Nursery Area (the Fleet);
- Crookhill Brickpits, Chickerell Local Nature Reserve (LNR); and
- Chiswell Walled Garden Doorstep Green.

In addition to the above, there are also a range of historic environment features and assets within and around the BMP area, including Scheduled Monuments, Listed Buildings and shipwrecks.

Further detail and discussion of the environmental characteristics relating to the BMP area are provided in **Section 2.8** and **Appendix B**.

1.3.2 History of Flooding

The Chiswell area has a long history of flooding, with the most infamous recorded event occurring in November 1824 when “*a hurricane blew up, overtopping the beach and sending a great sea surge through the village*” (Chiswell Community website(a)).

Table 1.1 provides a summary of a number (but not all) of notable storm events since the 1824 event and their recorded effects, as provided by the Environment Agency (2009a). This has been further supplemented with data from the SCOPAC *Historical Coastal Events Database* that was provided for the 2010 version of this BMP by Dr Malcolm Bray. Data was also utilised from the *Geology of the Wessex Coast* website (West, 2014). Unfortunately, locally measured information about the wave and water level conditions that caused these flooding events is generally not available as there has not historically been a reliable source from which to gather such information; the exception being the more recent 2014 events for which telemetry data from a variety of recording devices in the vicinity of Chiswell provides a detailed record (CH2M HILL, 2014a). **Figure 1.7** presents these events as a timeline.

Table 1.1 *Summary of notable historic flood events affecting the study area.*

Date	Effect	Comments/Other Information
23 rd November 1824	80 houses destroyed and 26 people drowned. The width of Small Mouth (Ferrybridge) increased by “five times”. 101 tonnes of sloop carried over the ridge of the bank. 80 tonne boat carried over the beach crest.	Fleet Level rose by 6.8m at Abbotsbury. Overwashing event possibly due to swell wave or bimodal wave condition within an exceptional storm.
22 nd November 1853	Chiswell percolation flooding and property damage.	Major flooding due to storm event.
2 nd December 1865	Railway undermined.	Percolation flood.
3 rd September 1883	Overtopping of beach. Water 4ft deep at station and destroyed near 1 mile of the Portland line.	South westerly gale.
13 th February 1899	Minimal damage	Percolation flood during storm event.
10 th October 1903	Victoria Square and Brandy Row affected.	Percolation flood during storm event.
6 th February 1904	Overtopping and preceding waves caused the bank to form one long slope rather than tiers. Beach recession resulted.	Large “tidal wave” hit at 6:30am – probable swell wave event. Gas supply cut for a day, water very muddy.
6 th January 1906	Gas works flooded by overwashing during storm event.	
20 th February 1910	Many houses flooded to 2ft (0.6m).	Percolation and overtopping flooding in 2 separate storm events.
13 th February 1914	Victoria Square flooded to 1.5ft (0.5m).	Overtopping flood. Storm or swell wave event.
14 th March 1914		Some overtopping, mainly percolation, during storm event. Minimal damage.
10 th January 1924		Severe flooding during storm event.
11 th November 1936	King Edward VIII train stranded in Chiswell.	Overtopping, some damage.
13 th December 1942	150 houses damaged and 6ft (1.8m) of water in Victoria Square left behind 6 inches (0.2m) of mud.	Severe flooding over 3 tides. Overtopping and percolation. Wind speeds of 80 mph. Anecdotal evidence of 60ft (18m) waves. Agreed to be the worst storm since 1824

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Date	Effect	Comments/Other Information
26 th October 1949	Railway embankment subsided. Victoria Square flooded to 2ft (0.6m) deep.	Wind speeds of 64 mph
27 th November 1954	The sea came surging over and up through the Chesil Beach swamping the main road to Portland. A stretch from Ferry Bridge to Portland Square lay under water up to a depth of 4ft (1.2m). in places. Wyke coastguards counted 30 holes (thought to be 'Canns') where the seas had worked through the Chesil Beach. A stretch of wall about 40ft (12m) in length skirting the oil tanks was smashed down.	Major overwashing and percolation during storm event.
1 st January 1962	Seawall undermined where sheet piling not completed – no structural damage.	Severe overtopping. No warning – came within 30 minutes.
2 nd February 1972		Percolation flood during storm event.
9 th February 1974	Victoria square flooded to 2ft (0.6m).	2 day storm, percolation flooding.
2 nd September 1974	Reports of sewage carried into houses by floodwaters.	Percolation flooding.
15 th October 1976		Percolation and overwash flooding at Victoria Square end.
13 th December 1978	30 properties flooded.	1 in 5-10 years. Short, steep locally generated wave action, wave period of 12s. Overtopping. Surge of 0.5m recorded and high SW winds.
13 th February 1979	30 properties flooded.	1 in 50 years, 4 hour warning. Major overwashing occurred only 2 months after previous event and resulted in a full breach at Chiswell. Long swell wave action (18 to 24 second period), developed from a depression in the mid-Atlantic travelling at the same speed (30 knots) as the storm waves, hence continuing to input energy.

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Date	Effect	Comments/Other Information
11 th April 1983	Victoria square 4ft (1.2m) deep, causeway road closed. Damage to beach crest and gabion cages.	Storm event, percolation flooding, short period event, period of 8s.
16 th December 1989	21 properties flooded, 8 damaged, 1 severely.	Storm overwash resulting in some damage but defences worked well.
3 rd January 1998		Percolation flooding and overtopping spray.
10 th March 2008		Storm and surge event, leading to percolation flowing into monsoon drain and spray overtopping.
14 th November 2009		Storm and surge event, leading to percolation flowing into monsoon drain and spray overtopping.
27 th June 2011		Swell wave (seiche) event, leading to percolation flowing into monsoon drain.
3 rd -4 th January 2014	A354 Portland Beach Road flooded. Road closed as a result.	Percolation through beach north-west of Osprey Quay and monsoon channel.
6 th -7 th January 2014		Event also caused damage to coastal defences. Flooding in Chiswell (but no reports of properties affected). A354 Portland Beach Road closed (but no evidence road flooded).
5 th February 2014	Flooding in Chiswell of about 6 properties. A354 Portland Beach Road flooded along much of its length. Road closed as a result for many hours.	Wave overtopping of defences and wave overwashing of shingle ridge/gabion mattresses, as well as percolation through the beach. Extensive damage to coastal defences and draw-down of large volume of beach material to nearshore area.
14 th February 2014	Flooding in Chiswell of about 6 properties. A354 Portland Beach Road flooded along much of its length. Road closed as a result for many hours.	

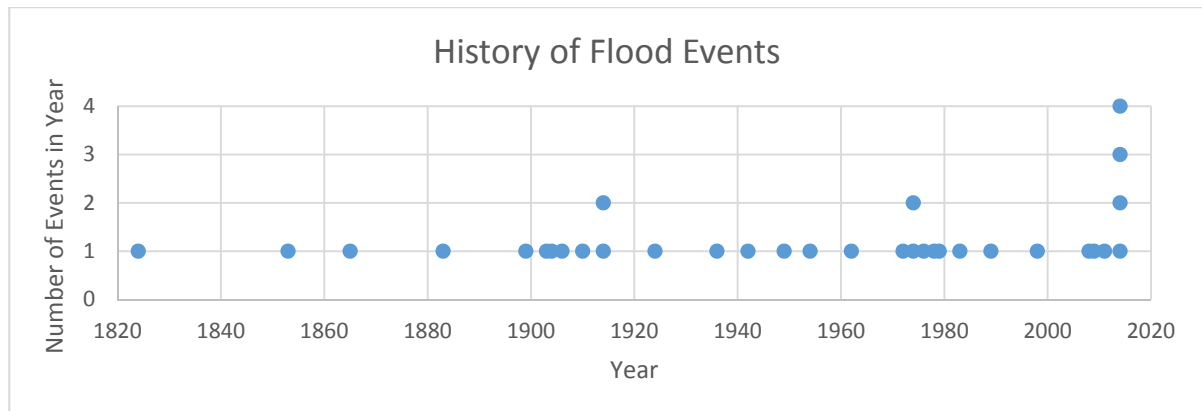


Figure 1.7 *Timeline of historic flooding events presented in Table 1.1.*

There is no obvious distribution to the historic events that have affected the south-eastern part of Chesil Beach that is the subject of this BMP, other than to note that there appears to have been a number of periods where events have occurred in clusters of greater frequency than other times, notably in the early 1900s and 1970s, although even within these two clusters the events were still infrequent enough to allow extended periods for the beach to recover between events. That cannot be said of the most recent cluster of storms that all occurred within less than two months in January and February 2014, in that there was only a matter of a few days or weeks between storms. This quick succession of storm events, which were all large storms in their own right (refer to **Section 2.6.4**) resulted in a cumulative effect of beach draw-down to the nearshore and damage to the coastal defences which were exposed to greater wave action as a result of reduced beach levels in front of the defences.

Other severe historic events occurred within the months of November to February and the 1824 event would appear to be the most extreme in terms of impact (Le Pard, 1999). The 1942 event also appeared to be the result of an especially extreme storm and the 1904, 1979 and 2014 events are especially noteworthy as they comprised large swell wave components that were very effective at overwashing the beach in the vicinity of Chiswell (refer to **Figures 1.8a and 1.8b**).

The importance of this analysis is that it provides evidence of the full range of events to which the beach is subject and underlines the fact that it is important to capture robust details about the causes and effects of large storm events at Chiswell to further aid understanding of the performance of the coastal defences and how to manage coastal flood and erosion risk at Chiswell in the face of large storm events that the area experiences.



Figure 1.8a *Overwashing of Chesil Beach during event in 1979 (Chiswell Community website (b)).*



Figure 1.8b *Overwashing of Chesil Beach during event on 5th February 2014 (from Environment Agency archive).*

1.3.3 Defence History

The first attempts at providing formal defences along the BMP frontage occurred between 1958 and 1965 when seawalls were built along about the same extent as seen at present, and slope stabilisation measures were installed in the West Weares landslip complex to reduce the risk of landslides in this area. The south-easternmost part of this seawall fronting West Weares was repaired in 2011, with exposed and corroded sheet piles at the base of the wall being encased in concrete that in turn provides a useful access platform from the steps at this end of the seawall to the beach.

The only other periods of significant coastal defence construction along the BMP frontage occurred in the 1980's when much of the present coastal defence system was constructed following a spate of flooding at Chiswell in the 1970s that caused by overtopping of the beach crest as a result of a combination of high tide levels and storms. The scheme that was designed aimed to reduce the potential for flooding at Chiswell village and the main road between Portland and Wyke Regis. Other works along the BMP frontage have occurred to repair or re-construct elements of the coastal defence system damaged during storm events, such as occurred to parts of the seawall and gabion castle and mattresses following the winter 2013/14 storms. Other repairs were carried out in 1990 and 2001, primarily to the gabion castle and mattresses.

The present coastal defences at Chiswell, that all work together to reduce the risk of coastal flooding, coastal erosion and landslides, are comprised of the following elements:

- **Seawalls** – Three distinct concrete seawalls were built between 1958 and 1984 to protect Chiswell. The two south-easternmost sections of seawall are the oldest and are complemented by drainage systems which help stabilise the coastal slopes behind (see **Figure 1.9a**). This reduces the risk of landslides along West Weares. They are managed by Weymouth & Portland Borough Council.

The third section of seawall was originally built in the 1960s. In the 1980s this wall was replaced with a new wall built over the top of the 1960s wall, and a curved section was also added to the top of the wall to reduce the amount of water coming over and into Chiswell (see **Figure 1.9b**). The lower part of this wall is managed and maintained by Weymouth

and Portland Borough Council. The upper wave return wall part (including the flood gates) is owned, maintained and operated by the Environment Agency.

- **Gabion castle and mattress** – Gabion wire baskets filled with beach material provide a transition between the seawall in front of the Cove House Inn and the natural Chesil Beach. These create the 'castle' structure and a further 550m of mattress layers (thin sloping gabions baskets) on top serve to prevent the crest of the beach being lowered when waves overtop the beach (see **Figures 1.9c and 1.9d**). These structures are managed and maintained by the Environment Agency.
- **Interceptor drain** – Running beneath the seawall (from the Cove House Inn) and the gabion mattresses is an interceptor drain. During storm events, large waves push seawater through the shingle beach. This drain prevents that water flowing through the beach and into Chiswell by diverting the water into the flood alleviation channel via 'the Windows' and ultimately into Portland Harbour (see **Figure 1.9e**). It is managed and maintained by the Environment Agency.
- **Flood alleviation channel (Monsoon drain)** – The flood alleviation channel is the open channel that runs beside the Portland Beach Road. This carries sea water from the interceptor drain into Portland Harbour via a culvert located beneath the road (see **Figure 1.9f**). It is managed and maintained by the Environment Agency.
- **Shingle beach** – This is an important part of the coastal defence system and the beach profile is monitored and managed in order to meet the requirements of this BMP.

Further details about the present coastal defences are provided in **Section 3.1**, whilst **Figure 1.10** provides an overview of the spatial relationship of the various defence elements and other key features of the BMP area.



Figure 1.9a View of the sea wall operated by Weymouth & Portland Borough Council (29th August 2014, courtesy of A. Frampton).



Figure 1.9b View of the sea wall operated by the Environment Agency (29th August 2014, courtesy of A. Frampton).



Figure 1.9c Re-constructed gabion castle (19th November 2014, courtesy of A. Frampton).



Figure 1.9d View north-west along the re-paired gabion mattress from the gabion castle (from Environment Agency archive).



Figure 1.9e View of 'The Windows' that mark the point where the interceptor culvert beneath the beach discharges into the flood alleviation channel (30th July 2014, courtesy of C. Weeks).



Figure 1.9f View along the Flood Alleviation Channel (also referred to as the Monsoon Drain) from the Portland Harbour end full as a result of percolation through the beach being diverted into the channel by the interceptor culvert (9th October 2014, courtesy of A. Frampton).

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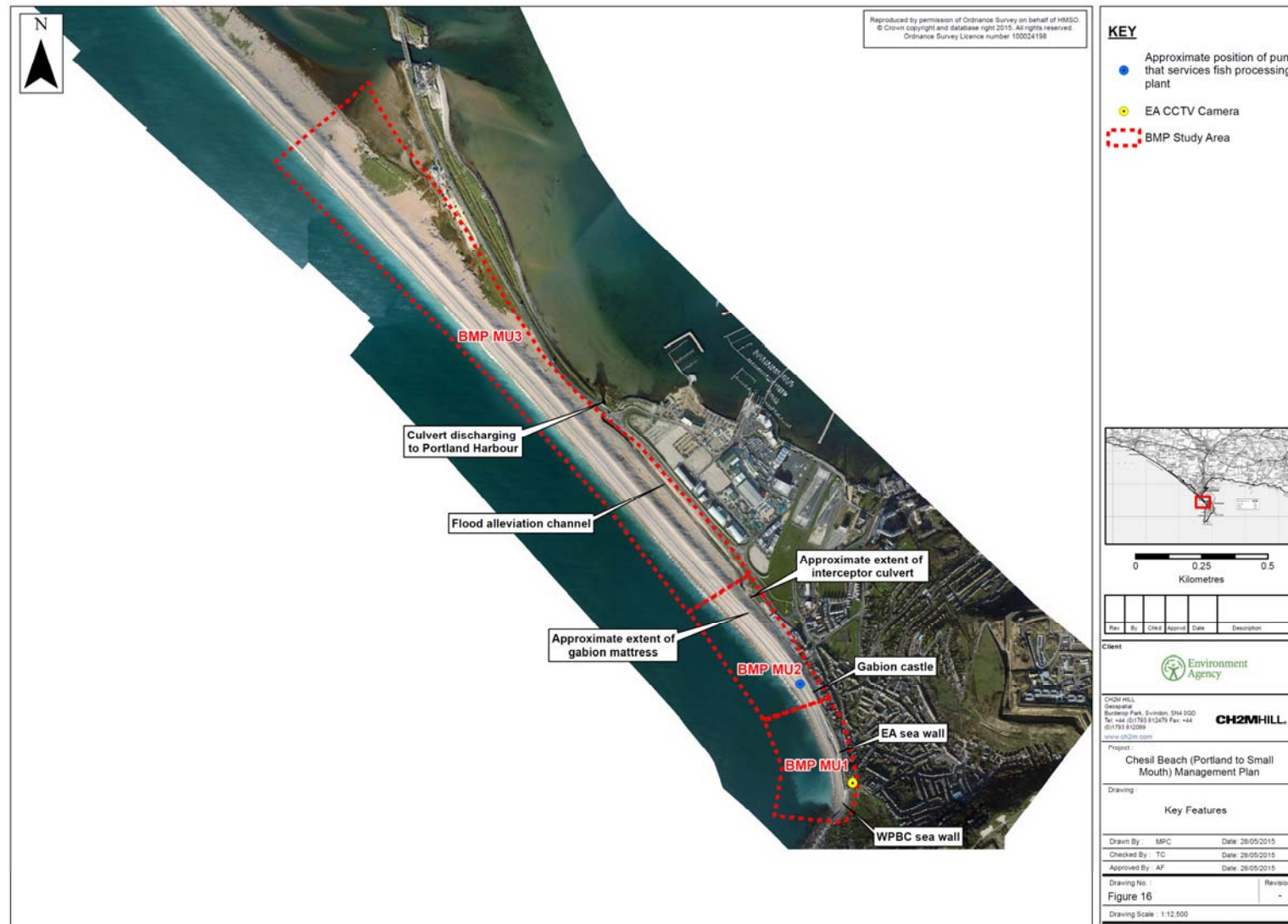


Figure 1.10 Key features along the BMP frontage.

1.3.4 Current Condition

The scheme constructed in the 1980's was designed with a 50 year design life (Environment Agency, 2009a). Following the repairs made in 2014 following the winter 2013/14 storms (refer to **Section 1.3.3**), the current condition of the various coastal defence elements along the frontage, based on visual inspection conducted in accordance with the *Condition Assessment Manual* (Environment Agency, 2012a) by the Environment Agency in April 2015 is assessed as being:

- WPBC seawall = 3 (Fair).
- EA seawall = 3 (Fair).
- Gabion Castle = 1 (Very Good).
- Gabion Mattress = 1 (Very Good).

Based on the findings of the visual inspection, the residual life of the seawall structures is determined based on *Guidance for Determining Asset Deterioration and the use of Condition Grade* (Environment Agency, 2009b). The residual life of the various coastal defence elements is assessed as being:

- WPBC seawall = 15-20 years.
- EA seawall = 15-20 years.
- Gabion Castle = 25-30 years.
- Gabion Mattress = 25-30 years.

With regards to the WPBC seawall constructed in the 1960s along with slope stabilisation measures in West Weares, the assessment made above can be compared to an assessment made in 2009/10 by Black & Veatch (2010), which determined that the WPBC wall at that time was in good to fair condition with a residual life of 15 to 20 years (although the south-easternmost part did require repairs that we completed in 2011 – refer to **Section 1.3.3**). The April 2015 assessment indicates the condition has not changed over the past five years. The stability of the seawalls within MU1 is dependent upon the steel sheet pile toes of the walls not being exposed by beach draw-down during storm events, and so it is important in this area that beach levels are above the sheet piling as much as possible. Retention of beach in the far south-east corner of MU1 for this purpose is difficult to achieve. As a result, rock armour has been placed in this area at the base of the wall to reduce the reflectivity of the wall, which is thought to be a factor in the low beach levels that persist in this area.

The condition and residual life of the gabion structures is dependent upon the frequency of large storm events impacting the area, and how those events draw-down beach material from in front of the gabions which in turn exposes a greater area of the gabions to wave action that causes the baskets to be ripped open.

In addition to the hard-defences along the BMP frontage, the beach is also an important factor in the overall coastal defence system. With reference to **Section 2.6.4**, most storm events historically have only caused small, temporary changes in beach levels in the areas of MU1 and MU2 where the beach provides natural protection to the hard-defences. However in the winter of 2013/14, the storms caused approximately 50% of the beach volume in MU1 and MU2 to be drawn-down the beach to the nearshore area, exposing in parts the underlying clay bed-rock that is prone to rapid erosion (see

Figure 1.11), thus increasing the risk of undermining of the seawalls, the steel sheet pile toes of which are driven into this clay bed layer (refer also to **Section 3.1**). This decreased beach level persisted for many months following the winter 2013/14 storms, and although much has returned, the beach volume along MU1 and MU2 in total remains about 10% lower in March 2015 than the volume before the storms in June 2013. However, even accounting for the beach volume being lower, based on the *Condition Assessment Manual* (Environment Agency, 2012a) guidance, the condition of the beach as of March 2015 is defined as being 'Good'.



Figure 1.11 Draw-down of beach following 14th February 2014 storm exposed clay-bed layer beneath beach (16th February 2014, courtesy of A. Frampton).

1.3.5 Amenity Value

The Dorset coast is a popular tourist destination and as such the local economy is heavily dependent on this source of revenue. Behind Chesil Beach there are a number of caravan sites at Wyke Regis, Abbotsbury, West Bexington, and Swyre, although only the Wyke Regis site is close to the area considered by this BMP.

Chesil Beach itself is popular for a range of activities including dog walking, storm watching, fishing/angling, beachcombing, bird watching and fossil hunting. Beach fishing focuses on nearshore wrecks and these are also popular for wreck diving which is accessible from the shore, with wrecks such as the Royal Adelaide being popular for this purpose. Sailing, windsurfing, kite surfing are also popular in this area but tend to be focused on the flat water of Portland Harbour and Hamm Beach where there are dedicated schools; participants in those activities utilise parking facilities at the Chesil Beach Visitor Centre located immediately behind the beach in MU3 (refer to **Figure 5.1** in **Section**

5.4.4). The visitor centre was expanded and improved in 2012, and as part of that work improved access over Chesil Beach from the centre was provided by constructing a timber walkway (**Figure 1.12**). Many visitors that access the beach from the visitor centre tend to walk towards the Carr Memorial Stone placed in the crest of the beach in this area, and a small depression thought to be caused by trampling is present here.

The back of the beach, seawalls and coastal slope located within the study area all form part of the South West Coastal Path. Part of the English Coast Path, designated in 2012 by Natural England under coastal access provisions established under the Marine and Coastal Access Act 2009; and the National Cycle Route 26, also run parallel to the A354 Portland Beach Road behind Chesil Beach, particularly within MU2 and MU3 (refer to **Figure 1.13**).

Recognition of the quality of sailing resource his evident from the presence of the Weymouth & Portland National Sailing Academy (WPNSA) which hosted the sailing events for the London 2012 Olympic and Paralympic Games and continues to host many sailing events annually. As part of the preparations for the 2012 games, significant investment was made (and continues to be made) in the Osprey Quay area situated behind Chesil Beach in MU2. This includes new commercial industry and a 600-berth marina and associated facilities and infrastructure.

In the Fleet rowing boats and canoes can be used but the use of sailing and motor boats is discouraged. Boats used on Chesil Beach are normally associated with fishing activities and often require registering.



Figure 1.12 Timber walkway across to the beach from the Chesil Beach Visitor Centre.

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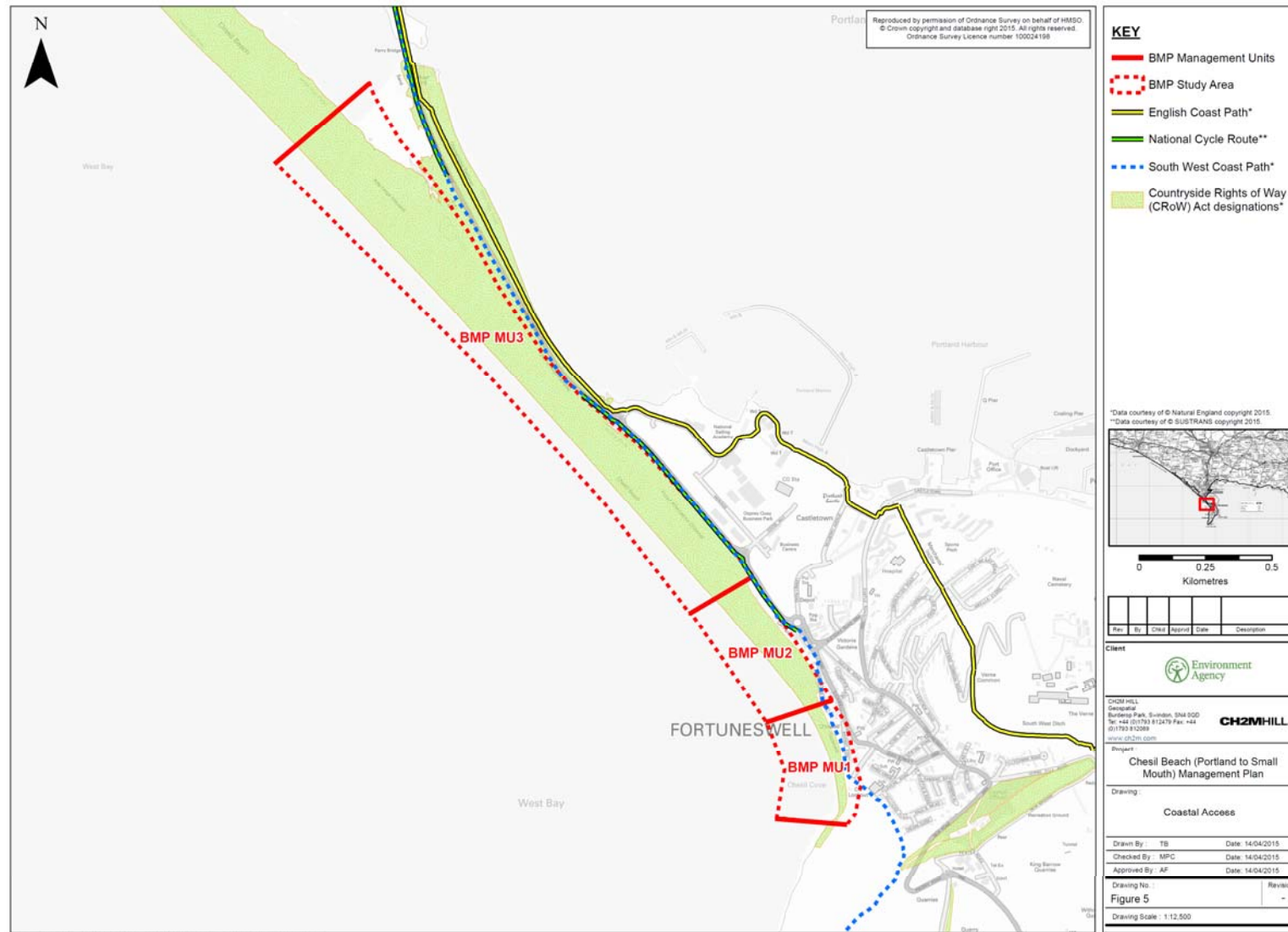


Figure 1.13 Coastal access designations.

1.3.6 Land Ownership

Chesil Beach is owned by multiple owners, each with their own access arrangements.

The southern end of Chesil Beach from Portland to Wyke Regis (the Weymouth and Portland Local Authority boundary at OS grid reference 645,776), and the part covered by this BMP, is owned by the Crown Estate and is Crown Common land (Chesil Beach website (a); see also **Figure 1.13** above). This ownership covers the back slope of the beach to the A354, including the area occupied by the interceptor drain, and the seaward slope down to Mean Low Water (and beyond). A small area of land at Chiswell behind the beach is owned by WPBC, though the majority of land in this area is in a variety of private ownership. In addition, a land registry search completed by the Environment Agency on 27th February 2015, indicate that part of the lower-slope of West Weares above the WPBC wall in MU1 appears to be in private ownership not WPBC ownership. **Appendix C** contains some additional information about land ownership that is relevant to this BMP.

The central section of Chesil Beach from Wyke to the Abbotsbury car park (OS grid reference 542,858) is owned by the Ilchester Estates and environmentally it is the most sensitive part of the whole of Chesil Beach (Chesil Beach website (a)). It is thought that Ilchester Estates own the beach down to the Mean Low Water mark, although this would need to be confirmed with the landowner as typically the Crown Estate owns the area below Mean High Water (Personal Communications, 12/02/2010 and 06/02/2010).

The National Trust owns a significant part of the beach beyond Abbotsbury towards West Bay.

The area behind Chesil Beach again has multiple private ownerships. Information about these owners has not been identified.

Whilst the beach is owned by the various landowners described above, the area of Chesil Beach covered by this BMP is also Registered Common Land. It is also designated under Section 15 of the Countryside and Rights of Way (CRoW) Act 2000. This designation means landowners and managers cannot use restrictions or exclusions under the CRoW Act 2000, but the area may have its own byelaws or other statutory controls to manage access arrangements (Natural England, 2014a). These areas are also shown on **Figure 1.13** above.

1.3.7 Highways, Services and Utilities

Under Chesil Beach at its eastern end are utilities infrastructure. These are gas mains, water pipes and electricity cables. The locations of these utilities are mapped on a number of drawings from previous studies, although no reference is made to the service providers and a search of these has not been undertaken as part of developing this BMP. Appendix D contains a copy of these services drawings for ease of reference although **new checks should be carried out before any works occur on site.**

Beneath the beach there is also a pump that allows exchange of sea water for a fish processing plant located to the east of the beach in Chiswell. The position of this pump is shown on **Figure 1.10**.

In addition to this, there is the main road (the A354 Portland Beach Road) that is operated by Dorset County Council's Highways Department.

1.4 Issues

1.4.1 Flood and Coastal Erosion Risk Management

1.4.1.1 Defining Standard of Protection (SoP)

The key issue at Chesil Beach is the need to provide a Standard of Protection (SoP) against the risk of flooding of at least the 1:12 year Return Period (8% APO) level for the seawalls in MU1, as designed for in the sea defence scheme constructed in the 1980's (refer to **Section 1.2**). Overtopping and overwashing risk analysis carried out in developing the 2010 version of this BMP (refer to **Section 3.2**) sought to confirm what the current SoP is along the BMP frontage, both for the present day (2010) and in 50 and 100 years' time, allowing for the effects of climate change (allowing 10% increase in wave height) and sea level rise; both of which were based on the Defra guidance at the time (Defra, 2006). That assessment of the SoP found that it is not possible to determine the SoP in any robust way as the methods available for undertaking the analysis are highly sensitive to the input parameters used, resulting in widely varying assessments of the existing (and future predicted) SoP. Further detail is provided in **Section 3.2**.

Furthermore, several of the winter 2013/14 storms that caused damage to parts of the defences and some flooding of Chiswell (but not to the extent of historic events pre-construction of the 1980s defence system – refer to **Section 1.3.2**), have been assessed as being in excess of 1:50 year (2% APO) events (refer to **Section 2.1.2**), well in excess of the design SoP of 1:12 year Return Period (8% APO) for the seawalls in MU1. In addition, there is also the risk of crest lowering and breaching along MU2 and MU3 that is not addressed in assessments of SoP in these parts of the BMP frontage, due to a lack of reliable measures.

As such, given the above issues regarding defining SoP along the BMP frontage, **consideration should be given to alternative ways of determining how the overall defence system performs during extreme events and thus how the SoP is defined**, as simply assessing SoP against wave overtopping (for which methods of assessment are only available to apply in MU1) is not an accurate reflection of how the overall risk to people and property is dealt with by the defence system that is designed to minimise and accommodate coastal flooding rather than prevent it.

1.4.1.2 Beach Maintenance Works and Flood Warning

The beach is currently maintained through occasional beach maintenance operations involving recycling and re-profiling of beach sediment from areas of accretion to wherever it is required along MU1 and MU2. The aim of this work in recent times (prior to 2014) has been:

- To ensure that at least 300mm of shingle covers most of the gabion mattress to reduce visual impact of the gabions (a condition of planning consent granted by WPBC when the gabions were installed);
- To push sediment back up the back slope of the beach to the crest in the area of the Masonic Car Park that gets pushed down the back slope by beach users accessing the beach from the car park (see **Figure 1.14**). *NB: sediment is not, and should not be, moved from the back slope of the beach to the front slope on the Lyme Bay side under any circumstances; and*
- To remove sediment accumulated against the re-curve of the seawall so that waves do not run-up over the beach and seawall. From discussion with the Environment Agency

Operations Delivery Team, the beach level against the seawall is to be no more than 1.5m from the wall crest.

During and following the winter 2013/14 storms, beach recycling and re-profiling occurred on a near continuous basis between January and February 2014 to attempt to pull material drawn-down the beach to the nearshore back up the beach slope to cover the base of the gabion mattress and castle and steel sheet-pile toes of the seawalls (**Figure 1.15**). Further beach recycling and re-profiling occurred over a two week period in late September 2014 as part of works to finalise the repairs of the gabion castle and mattress. In doing so an effort was made to create berm features at several levels along the beach slope to replicate the natural profile of the beach. The effectiveness of these recycling works needs further investigation as part of the detailed review and update of the coastal processes understanding recommended in **Section 1.4.4**.



Figure 1.14 Re-profiling the back slope of the beach in the vicinity of the Masonic Car Park (from Environment Agency photo archive).



Figure 1.15 Beach re-profiling the beach face on 9th February 2014 (courtesy A. Frampton).

These beach management works are undertaken to try and ensure that the beach forms an effective part of the overall coastal defence system at Chiswell. However, beach management and maintenance of the hard-defence structures alone can only provide protection to parts of Chiswell under relatively small locally generated and swell wave events. If a large locally generated or swell wave event were to occur, as has happened historically and most recently over the winter of 2013/14, then it is unlikely that the defences here will provide complete protection against flooding. Indeed, there is potential for catastrophic and rapid inundation should overwashing as a result of a large swell or storm wave event occurring. In addition, the A354 Portland Beach Road is at significant risk of flooding via percolation through the beach, either directly or when volumes flowing through the interceptor culvert/flood alleviation channel exceed the system capacity and/or are prevented from discharging by high-tide levels in Portland Harbour.

As such, there is a reliance on flood warning procedures to be able to provide adequate warning time to evacuate flood risk areas should a large event be predicted (refer to **Section 4.5**). However, there are a number of issues that have been identified with the data utilised for flood warning purposes at

Chiswell, which the *Understanding Barrier Beaches* report (Defra/EA, 2008) described as being a low key and largely ineffective flood forecasting system due to the following reasons:

- **Wave and Tide Data** – The Met Office forecast is the only source of swell wave data available to the EA and a recent breakdown in the supply of this data (though now rectified) resulted in this information not being available to be considered for a period of time; an evident weak link in the system.

The PCO wave buoy data (refer to **Section 2.1** of this BMP) is insufficient to cover this. There are also differences between how the wave buoy defines wave climate and how the Met Office model defines it (refer also to the discussion in section 2.1 of Appendix E regarding the accuracy of Met Office modelled data compared to site measured data).

- **Wind Data** – No wind data is currently recorded at Chiswell. Recording of wind data is important as the wind speed and direction can have a significant impact on flood risk.

NB: Wind data is now recorded in the vicinity of the BMP area at two locations (refer to **Section 2.1.3** of this BMP).

- **Beach Data** – Beach sediment size and its impact on beach porosity, and so flood risk, is not well understood (refer also to **Section 2.5.1** of this BMP).

In summary, there is presently limited data available to understand these large events and how they may impact upon Chesil Beach and the low-lying land it protects. There is also no reliable means to accurately predict the likely impacts of such events at Chiswell to give adequate flood warning. Therefore it is vital that emergency plans (refer to **Section 1.7.9**) are robust and set out measures to be taken should a large event occur to the extent that has occurred in the past. To date, only analysis of monitoring data and associated impacts relating to the winter 2013/14 storms has been undertaken (CH2M HILL, 2014a) and **further investigation in this area should be considered**.

In addition, **ensuring public awareness and education of the flood risks is maintained should form a key part of the ongoing strategy in this area**. The Environment Agency already has a programme of raising public awareness in the Weymouth and Chiswell area, including regular flood warning siren testing events for the community at Chiswell, and this programme is to continue. In addition, a booklet about the coastal defences and impacts of storms in the winter of 2013/14 was produced in April 2015 with the support of the Dorset Coast Forum. A copy of this booklet is provided in **Appendix Q**.

1.4.2 Environmental Constraints

When undertaking beach maintenance works there are a number of environmental issues to be addressed (refer also to **Sections 1.3.1 and 2.8**). The following environmental constraints have been identified for the BMP area:

- Access to the south-eastern part of the site (MU1) is from the Masonic Car Park in MU2, where a compound is to be established in an area that does not impact upon features of designation in this area (i.e. vegetated shingle habitat). Access to the area towards Small Mouth (MU3) would be from either the lay-by adjacent the Portland Harbour Culvert at the north-west end of the flood alleviation channel or, in exceptional circumstances, the Visitor Centre car park. In accessing the beach from either of these areas, there is a need to avoid

impacting upon areas of vegetated shingle. Access also requires heavy plant moving over the beach that can impact upon the pebbles and so use of suitable plant is needed to minimise this impact. Further details about access for works and other works implementation issues is provided in **Section 5.4**.

- Works need to be mindful of utilities and other assets e.g. outfalls/intakes beneath the beach. Vibration and heavy plant can impact upon these.
- There is potential for recycling/re-profiling works to impact upon the following:
 - Features of designation of the SAC;
 - SPA;
 - SSSI;
 - MCZ;
 - Ramsar site;
 - NCA;
 - Heritage Coast; and
 - UNESCO World Heritage Site.

As noted in **Section 1.2**, **a Habitats Regulations Assessment should be completed alongside any future update of this BMP, in line with the requirements of the Conservation of Habitats and Species Regulations (2010) or any superseding requirements in place at the time,** to ensure that the updated management regime identified in any future BMP does not cause significant adverse effects for the features of interest of the site. Such an assessment should also draw upon information from the Habitats Regulations Assessment completed for this version of the BMP, a copy of which is provided in **Appendix A** for ease of reference.

- Visual impact of carrying out works within landscape designated area (Heritage Coast, World Heritage Site).
- The beach in MU3 is a breeding and nesting site for species listed in the Chesil Beach and Fleet SSSI citation.
- There is currently a lack of monitoring of designated habitats/species to appraise impacts on sites covered by the Habitats Regulations.

1.4.3 Public Safety and Amenity Constraints

As noted in **Section 1.3.5**, Chesil Beach and the surrounding area is a popular destination for a range of amenity uses. The use of the beach varies depending on the season and facilities such as the Chesil Beach Visitor Centre provide a focus for amenity use and access onto the beach.

In order to avoid disruption to peak summer use of the beach, maintenance works are to be undertaken in the off-peak months between October and March so far as possible, though experience following the winter 2013/14 storms proved it may at time be necessary for works to occur during the spring and summer. Even with works undertaken during this period, there are still a sizeable number of people likely to visit the beach, particularly at the Chiswell end, at this time of

year and so a compound should be established for all plant and equipment. Measures to ensure safe public access to the beach, for example through the use of signage and temporary diversions to the coastal path, should also be utilised, although experience during works along MU1 and MU2 during and following the winter 2013/14 storms suggests this may have limited success. Measures to address this are described in **Sections 5.1.3 and 5.4.5**.

In addition to maintaining public safety when works occur, other amenity and public safety issues exist at the site that relate to the structures. These include:

- Varying beach levels at the south-eastern end (fronting the WPBC seawall) pose access and fall issues (particularly where there are no hand-rails provided) as well as create risk of undermining to sea wall at that end.
- Health and safety issues associated with the gabion castle and mattresses:
 - Exposure of mattresses resulting in trip hazard and exposure of rusting/broken (protruding) baskets or wires and mesh.
 - Undermining of gabions could result in collapse.

These issues can in part be addressed through beach management activities by ensuring that sufficient beach material is present in each area to reduce fall distance and cover gabions to reduce trip hazards. However, it is known that to achieve this along the entire BMP area is already not possible due to a range of factors including localised sediment transport at the south-eastern end of the site and the steepness of the gabion mattress towards the gabion castle.

1.4.4 Uncertainties about Coastal Processes

Critical to the ongoing and future management of the beach is a thorough understanding of the coastal processes at work within the eastern part of Lyme Bay and along Chesil Beach. Overall, the broad-scale processes that affect Chesil Beach are not very well understood, with much uncertainty about forcing and response mechanisms that need to be resolved in order to improve future management decisions. Chesil Beach is a unique and extreme landform in terms of its scale, morphology and sedimentology and so perhaps it should be no surprise that it is very difficult to model and predict its behaviour using available methods. The uncertainty in this area is also due to there being limited quantitative data being available especially for very infrequent extreme events. This means it is difficult to predict future evolution or the SoP offered along this frontage in a way that can provide robust evidence-based mechanisms for guiding future maintenance works. Further discussion of the coastal processes understanding is provided in **Section 2** and **Appendix E** of this BMP.

Actions to address the current uncertainty in the coastal processes understanding, in order to improve the information on which future management of the area can be based, are a key focus of the management regime recommendations in this BMP. The aim of this will be to undertake a much greater amount of monitoring and additional routine analysis of monitoring data in the period before the next BMP review (in 5 years' time – refer to **Section 1.2**). To aid this, changes to how post-storm (and possibly pre-storm) surveys are triggered could also be made – perhaps making use of additional visual information from those on site such as the Chesil Beach Warden, who has previously recorded details of storm events (Moxom, 2009).

Whilst this additional monitoring is being undertaken to inform longer term management decisions, there will be a continuation of current practices of occasional, reactive beach recycling and re-profiling, especially along MU1 and MU2. This will be informed by comparison of beach level against the seawall to the seawall toe levels in MU1, and the toe level of the gabion mattress in MU2. The BMP also includes some formalisation of how works are carried out and what information is recorded when works occur. This situation can then be revised in 5 years' time when more data is available to inform management decisions. At this time it may be possible to derive further trigger levels based upon assessment of changes in the SoP if possible (refer to **Section 1.4.1.1**). For example, new methods of analysis may become available in the interim period and having improved monitoring data at this site will mean the application of such methods to Chesil Beach may be more practicable than at present.

To further support this, it is recommended that a more detailed review and update of the coastal processes understanding presented in Appendix E be undertaken. This should draw upon the monitoring data collected since 2007 and in particular, the data collected during and since the winter 2013/14 storms to assess, amongst other things:

- The extent of draw-down of the beach against the seawall and recovery of beach levels during and immediately following storm events, using data from University of Plymouth for the 5th February 2014 storm; and
- The impact and effectiveness of beach recycling activities in beach recovery operations following the winter 2013/14 storms (refer to **Section 1.4.1.2**), utilising both beach profile survey data, LiDAR data and bathymetry survey data collected by the Environment Agency and PCO.
- The wave and water level climate experienced during the winter 2013/14 storms, including the bi-modal nature of the events (refer to **Section 2.1.2**) and the extreme joint probability of the events (refer to **Section 2.3**).

This updated analysis could also usefully:

- Include analysis of data to the north-west of the BMP study extent (i.e. at least towards the Bridging Camp and possibly beyond) to assess changes in Chesil Beach in that area and investigate if any sediment moved from the BMP area to here during the winter 2013/14 storm events. This could be achieved using LiDAR data to assess profile changes along positions defined by Duane and Bray (2005), alongside any other available survey data that may have been captured in this area by others (e.g. The Fleet Study Group); and
- Reflect any findings from recent R&D work such as that by University of Plymouth, ongoing R&D such as that by SCOPAC and HR Wallingford, and any future planned R&D to address any of the uncertainties (refer to **Appendix F**).

1.5 Responsibilities

Responsibility for the management and operation of activities along the Chesil Beach (Chiswell to Small Mouth) frontage varies depending upon the activity. **Table 1.2** summarise the roles and responsibilities.

Table 1.2 *Assigned responsibilities for Chesil Beach (Portland to Small Mouth) management operations.*

Management Operation		Assigned Responsibility
1	Operations to maintain beach profile and maintain cover to gabions mattresses.	Environment Agency
2	Cleaning/clearance of promenade, steps, revetment, for amenity (<i>cleaning by WPBC involves use of a mini-sweeper to sweep the promenade 3 times a week. The frequency increases, as required, during the summer</i>).	WPBC
3	Cleaning/clearance of beach (<i>hazardous material only including animal carcasses, as required, on behalf of The Crown Estate</i>).	WPBC
4	All structural maintenance of promenade, seawall, revetment, gabions, beach access structures, slope stabilisation measures and flood gates.	Environment Agency / WPBC
5	All maintenance of access steps and ramps to beach from seawalls	WPBC
6	All maintenance of footpath and cycleways including signs for designated public footpaths and rights of way (<i>which covers the paths from Brandy Row up the coastal slope to West Weare</i>).	WPBC
7	Litter clearance	Dorset Waste Partnership
8	Monitoring of shingle movement (and other coastal processes), including pre- and post-storm profile surveys	South West Regional Coastal Monitoring Programme (PCO)
9	Maintenance of seats, litter bins etc	WPBC / Dorset Waste Partnership
10	Flood warning and response actions	Environment Agency
11	Maintenance of CCTV system	Environment Agency
12	Monitoring of ground water level data	Environment Agency
13	Emergency planning	DCC / WPBC

Actual ownership of the assigned responsibility for each management option identified in **Table 1.2** is in some cases held by different departments within the identified organisation. Therefore, in order to support **Table 1.2** and to provide clarity on who should be contacted for each item, **Appendix G** provides contact details for each management operation (**Section G.1**) as well as other organisations with interests in this area (**Section G.2**).

1.6 Licences, Approvals and Consents

In order to undertake any future FCERM activities along the BMP frontage such as beach recycling/re-profiling, repairs to coastal defences, or any associated detailed site investigations as may be required, a range of licences, approvals and consents may be required, including:

- Marine Licence under the Marine and Coastal Access Act 2009.

- SSSI consent from Natural England.
- Planning Application under the Town and Country Planning Act 1990.
- Crown Estate licence for maintaining boreholes within the beach.

The following sections summarise the consents that may be required and the processes to obtaining them.

Discussions should be held with the relevant consenting organisations in a timely manner to ensure that all requirements of licence/consent applications are confirmed and either addressed in order to minimise the risk of delays in being able to implement works, or letters of comfort stating explicitly the activities that do not require specific consent. Where necessary, these discussions should also assess the applicability of progressing any required licence application through the streamlined process defined in the Coastal Concordant for England published in November 2013 (Defra, 2013).

1.6.1 Marine Licence

At present along the BMP frontage no Marine Licence is held to facilitate beach management works that may be required within the next 5 years (between 2015 and 2020) until the next BMP review. To implement beach recycling or any other works along the BMP frontage, the Marine Management Organisation (MMO) will need to be engaged in the following ways:

(a) Beach recycling works

It should be noted that the MMO guidance has previously advised that beach recycling activities within the same sediment cell are exempt from the need for a marine licence. However, there is still a need to notify the MMO of a licence exempt activity, which in the case of the Chesil BMP works, has been notified via the MMO website (refer also to **Appendix R**). Should the MMO not agree with the exemption they will notify the applicant (usually within a week). In this instance the MMO did not object to the exemption submitted on the 17th June 2015 for beach management at Chiswell (EXE/2015/00048).

In addition, when undertaking beach recycling works along the BMP area, **consent is still always needed from Natural England each time works are carried out in the SSSI area.**

(b) Other works

For works other than recycling of sediment within the sediment cell (e.g. capital works; repair/replacement of structures), then a Marine Licence is likely to be required.

The process of obtaining a Marine Licence will require consideration of the Marine Work (Environmental Impact Assessment) Regulations 2007 to determine whether an environmental impact assessment is required. The MMO would most likely act as the Competent Authority in this regards.

A Water Framework Directive (WFD) Assessment may also be required to support any Marine Licence application. The scope of any such assessment would require consultation with the Environment Agency.

As there are also areas in the immediate vicinity of the study area that are designated under The Conservation of Habitats and Species Regulations 2010, a Habitats Regulations

Assessment will also need to be undertaken as part of any Marine Licence application. The Competent Authority for this would be Natural England (refer also to **Sections 1.2 and 1.4.2**).

Due to the time-scale involved in obtaining a Marine Licence (typically 14 weeks), it is strongly recommended that should a Marine Licence be required, then it should be sought from the MMO in good time to enable any works to be implemented when it becomes required, rather than having this 14 week delay at a time when such a delay may increase risk of failure of the seawall, etc. Any Marine Licence should be kept up-to-date so there is no lapse. It may be pertinent to seek a Marine Licence in the immediate future that would facilitate undertaking emergency works in the period to the next BMP review in 2020.

As for beach recycling works, even if a Marine Licence is not required to undertake works along the BMP area, consent is still always needed from Natural England each time works are carried out in the SSSI area.

1.6.2 Planning Consent

In addition to the above, any works may also require some form of planning consent from WPBC. Advice from WPBC in 2015 is that ordinary beach management operations do not require planning consent, but any construction of new structures or import of material would require planning consent (refer also to **Appendix R**). Should it be required, it is recommended that the local planning officer be consulted at the time when works are being developed to determine the most appropriate route for planning consent.

Above the MHWS the planning authority would act as the Competent Authority and planning permission would be sought. An application under these circumstances would also require consideration under the Town and County Planning (Environmental Impact Assessment) regulations 2011. In this regard, WPBC would likely act as the Competent Authority.

1.6.3 Crown Estate Licence

Ongoing monitoring of water levels within the beach from boreholes in MU2 (refer to **Section 4.1.9**) to measure the saturation of the beach is licensed by The Crown Estate Commissioners and costs £150 per annum (Environment Agency, 2009a).

1.7 Linkages to Other Relevant Documents

1.7.1 Shoreline Management Plan Policy

The first generation Shoreline Management Plan (SMP1) for the Chiswell end of Chesil Beach was completed in 1998 (Posford Duvivier, 1998a). The SMP1 policy recommended for this section of coast was 'Selectively Hold the Line', becoming 'Do Nothing' towards the Fleet. The SMP1 policy for the adjacent section of coast along the western side of the Isle of Portland was also 'Do Nothing'.

These policies were reviewed as part of the South Devon and Dorset Shoreline Management Plan Review (SMP2) and **Table 1.3** summarises the policy options contained in the Final SMP2 adopted in 2011 (Halcrow, 2011). **Figure 1.1** above shows how these Policy Units relate to the three Management Units considered in this BMP.

Table 1.3 *SMP2 policies adopted in 2011 (Halcrow, 2011).*

Policy Unit	Short Term (to 2025)	Medium Term (to 2055)	Long term (to 2105)
6a01 - Portland Bill to West Weare	Allow natural coastal evolution to continue through No Active Intervention .	Allow natural coastal evolution to continue through No Active Intervention .	Allow natural coastal evolution to continue through No Active Intervention .
6a02 - Chiswell to Chesil Beach	Maintain existing defences in order to Hold the Line and provide continued protection to existing assets.	Maintain or improve existing defences in order to Hold the Line and provide continued protection to existing assets.	Maintain or improve existing defences in order to Hold the Line and provide continued protection to existing assets.
6a03 - Chesil Beach (to Wyke Narrows)	Intervene to restore the defence function of the undefended beach only if required following storm events under a policy of Managed Realignment .	Intervene to restore the defence function of the undefended beach only if required following storm events under a policy of Managed Realignment .	Intervene to restore the defence function of the undefended beach only if required following storm events under a policy of Managed Realignment .
6a04 - Chesil Beach and the Fleet	Allow natural coastal evolution to continue through No Active Intervention .	Allow natural coastal evolution to continue through No Active Intervention .	Allow natural coastal evolution to continue through No Active Intervention .

One of the key points from the SMP2 is that it is assumed that beach management along the undefended part of the beach in Policy Unit 6a03 (BMP MU3) would only occur to restore the defence function of the beach following a large event in order to restore protection to key economic assets that run behind the beach, notably the A354 Portland Beach Road that provides the only access link to the Isle of Portland.

The policy for Chiswell is to continue to provide protection against the risk of flooding and erosion in the long term.

1.7.2 Related Asset Management Plans

In addition to this BMP, some of the various coastal defence elements along the BMP frontage have their own separate Asset Management Plans held by the Environment Agency in Blandford. These need to be referred to alongside this BMP and are as follows:

- Operation and Maintenance Manual for the monsoon drain (flood alleviation channel).

1.7.3 Weymouth & Portland Planning Policy

The following section summarises local planning policies that are relevant for coastal erosion risk management activities defined in this BMP.

1.7.3.1 West Dorset, Weymouth & Portland Local Plan (2015)

West Dorset District Council and Weymouth & Portland Borough Council have prepared a joint Local Plan.

The *Local Plan* was adopted by WPBC in October 2015 and contains policies and proposals for development in the area. It sets out the vision, objectives and spatial strategy for the area up to 2031. WPBC's vision for the area is to make it *"a place where people of all ages will be engaged with their local community, [and] feel a real sense of belonging and civic pride."* It also identifies the relationship with the sea as being an important part of the area's identity and so the vision also wants *"to keep the individual identities of the communities that make up our area, linking to our maritime heritage and the beautiful coastal and rural landscape, but always looking to the future."*

Relevant policies for this BMP aligned to the vision contained in the *Local Plan* are:

- ENV 1 (Landscape, Seascape and Sites of Geological Interest).
- ENV 2 (Wildlife and Habitats).
- ENV 4 (Heritage Assets).
- ENV 5 (Flood Risk).
- ENV 6 (Local Flood Alleviation Schemes).
- ENV 7 (Coastal Erosion and Land Instability).
- PORT 1 (Osprey Quay).

1.7.3.2 West Dorset, Weymouth & Portland Coastal Risk Planning Guidance, 2013

The *West Dorset, Weymouth and Portland Coastal Risk Planning Guidance* (Halcrow, 2013) identifies that the area covered by this BMP should be included within any future Coastal Change Management Area (CCMA) to be developed by the Local Planning Authority due to the future potential of increased risk from coastal change from both landsliding in West Weares and roll-back of Chesil Beach towards Portland Harbour (refer also to **Section 2.6.5**).

It also identifies that certain types of time-limited development could occur in areas of risk subject to a number of planning application requirements, specifically geotechnical and vulnerability appraisals. Where permanent development is allowed to occur in the flood risk zone, it also makes recommendations for development control/planning requirements to include within developments appropriate resilience to flood risk defined. This is in line with the strategic approach to environment and climate change set-out in the draft Local Plan (refer to **Section 1.7.3.2**).

1.7.4 Jurassic Coast World Heritage Site Management Plan, 2014-2019

The UNESCO Dorset and East Devon Coast World Heritage Site Management Plan (Jurassic Coast, 2014) defines a number of aims and objectives for the long-term sustainable management of the site. The aim is 'to protect the Site's Outstanding Universal Value (OUV) and setting'.

In line with this aim, the management plan sets out a range of policies covering all aspects of coastal management. The following policies are of particular relevance to the future management of the BMP area:

- Policy 1.1: Protect the OUV of the Site through prevention of developments that might impede natural processes, or obscure the exposed geology, as set out in the GCR / SSSI details, now and in the future.
- Policy 1.2: Where developments affecting the Site or setting do take place, avoid or at least mitigate negative impact on the natural processes of erosion and exposed geology.
- Policy 1.3: Oppose developments in the Site's setting that may warrant a future need for coastal defences, particularly in light of potential sea level rise and extreme weather events.
- Policy 1.4: Protect the landscape character, natural beauty and cultural heritage of the Site and setting from inappropriate development.
- Policy 1.5: Ensure that the 'South Devon and Dorset', and 'Two Bays' Shoreline Management Plans continue to take full account of the OUV of the Site and the specific geological and geomorphological features in the GCR sites when defining actions for coastal defences.
- Policy 2.14: Promote research that informs conservation and sustainable management of the Site and furthers the advancement of science that underpins its OUV.

1.7.5 Dorset Coast Strategy, 2011-2021

The *Dorset Coast Strategy* (Dorset Coast Forum, 2011) is a high level non-statutory document that provides a framework for how members of the Dorset Coast Forum, of which WPBC and the Environment Agency are members, can improve the planning and management of the Dorset Coast and inshore waters.

The goals of the strategy include establishing integrated coastal policy, identifying strategic opportunities for resource development, engaging and developing participation of a wide range of partners, and identifying solutions for sustainable coastal development, management and access.

These goals should be considered in all management decisions in this BMP area.

1.7.6 Dorset AONB Management Plan, 2014-2019

The Dorset AONB Management Plan (Dorset AONB Partnership, 2014) contains a number of objectives and policies deriving from ten main themes that include: Landscape; Biodiversity; Geodiversity; Coast and Sea; Historic and Built Environment; and Planning, Infrastructure and Highways.

Of particular relevance to this BMP are the objectives and policies under the Coast and Sea theme, which include:

- **Objective CS1:** Conserve and enhance the coast and marine environment of the AONB through integrated management that recognises the links between land and sea.
- **Objective CS2:** Support the natural evolution of the coast, allowing natural coastal processes to operate where possible.

1.7.7 Chesil Beach & The Fleet Site Improvement Plan, 2014

Site Improvement Plans (SIPs) have been developed by Natural England for each Natura 2000 site in England as part of the Improvement Programme for England's Natura 2000 sites (IPENS). Natura 2000 sites is the combined term for sites designated as Special Areas of Conservation (SAC) and Special Protected Areas (SPA).

The SIP covering Chesil Beach & The Fleet was published in 2014 (Natural England, 2014b) and provides a high level overview of the issues (both current and predicted) affecting the condition of the Natura 2000 features on the site(s) and outlines the priority measures required to improve the condition of the features. It does not cover issues where remedial actions are already in place or ongoing management activities which are required for maintenance. This includes actions regarding inappropriate coastal management with relation to vegetated shingle habitat.

1.7.8 South Inshore and South Offshore Marine Plans

The BMP area lies within the South Inshore Marine Plan area. This Marine Plan is currently being developed by the Marine Management Organisation (MMO) in parallel to the South Offshore Marine Area. Once published and adopted, the Marine Plan will be a statutory planning document used to guide licence and consent decisions within the marine environment up to the MHW mark including beach management activities (refer also to **Section 1.6.1**).

The final South Inshore and South Offshore Marine Plans are expected to be adopted in 2016, with a six-year review period.

1.7.9 South West River Basin Management Plan, 2009

The South West River Basin Management Plan (Environment Agency, 2009c) was prepared under the Water Framework Directive (WFD) as a product of the first of a series of six-year planning cycles. It contains actions to improve the ecological status of water bodies in river basin catchments, including coastal waters out to 1 nautical mile. The BMP area lies within one such WFD Coastal Water Body and so activities need to comply with the requirements of this plan.

1.7.10 Chiswell Operational Response Plan

The current emergency plan is the *Chiswell Operational Response Plan*. This is published and kept under review by emergency planning teams in Dorset County Council and Weymouth & Portland Borough Council. **The Environment Agency should continue to work with these organisations to develop future revisions of this emergency plan** to ensure that the risks identified in this BMP are addressed in the plan. This could include consideration of evacuation routes for residents and restoration of the beach defence function and transport links (should the A354 be affected).

1.7.11 Dorset Coastal Pollution Clearance Plan, 2010

The *Dorset Coastal Pollution Clearance Plan* (Dorset County Council Emergency Planning Service, 2010) defines the details the shoreline clean-up operational procedures to be followed in the event of a coastal/marine pollution incident from Oil, Inert, Hazardous and Noxious Substances (HNS). This includes any substance that is liable to create hazards to human health, harm to living resources and marine life, to damage amenities or to interfere with other legitimate uses of the coast line.

1.7.12 Dorset Coastal Rock Fall and Landslide Protocol, 2013

The *Dorset Coastal Rock Fall and Landslide Protocol* (Dorset County Council Emergency Planning Service, 2013) aims to establish the Multi-Agency response to reduce the risk of accidents associated with landslides or rock falls along the Dorset coast.

It seeks to achieve this aim by:

- Defining the roles and actions of agencies involved in the prevention and management of rock fall/landslide incidents
- Defining the roles and actions of agencies involved in the monitoring of existing rock falls/landslides and precautionary measures that can be taken to avoid potential incidents.
- Facilitating a co-ordinated and effective multi-agency response to such incidents.
- Defining the roles and responsibilities of agencies involved in the short, medium and long term Recovery phase and ensure that follow-up actions and an 'exit strategy' is carried out.

1.7.13 Other Information

A full list of reports and other documents relevant to the development of the present situation at this south-eastern end of Chesil Beach is provided in **Appendix H** of this BMP and should serve as an inventory of background information for anyone approaching the management of this part of Chesil Beach in the future.

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This section of the BMP provides a summary of the coastal processes that affect the south-eastern end of Chesil Beach between Chiswell and Wyke Narrows, both along the frontage and also its interaction with the rest of Chesil Beach to the west of Wyke Narrows (towards West Bay) as well as within the context of the wider area of Lyme Bay. The aim of this is to provide ready access to key information to inform beach and coastal risk management decisions along the BMP area. Greater detail about the coastal processes, from which this section is summarised, is provided in **Appendix E**.

2.1 Wave & Wind Climate

2.1.1 Typical waves

Chesil Beach is a barrier beach that is directly exposed to south-westerly Atlantic waves between a 'window' of 215° to 240° that is delimited by Start Point and the north-western coast of Brittany, France (Bray *et al*, 2004). This is reflected in data from the wave buoy deployed on about the -10mCD contour offshore of Chesil Beach as part of the South-West Strategic Regional Coastal Monitoring Programme (and run by Plymouth Coastal Observatory, PCO) that has shown since 2007 the majority of waves, including the largest waves, that affect the south-eastern end of Chesil Beach have come from the 210° to 240° direction sector (see **Figure 2.1**).

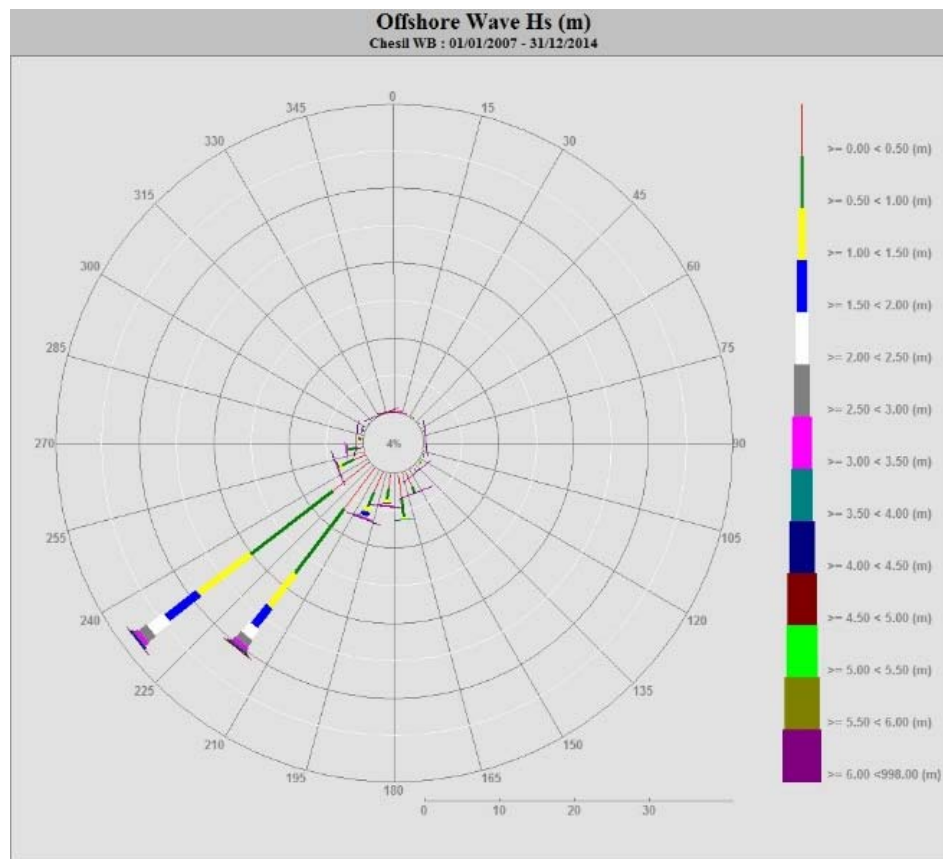


Figure 2.1 Wave rose from PCO Chesil Beach Wave Buoy at Chesil Beach covering the period 01/01/2007 to 31/12/2014.

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Some larger waves also come from the 180° to 210° sector, however these are far less frequent compared to the dominant sector. This south-westerly dominant pattern is also shown in the nearshore wave climate data for Chesil Beach derived from Met Office hindcast data for data point 365 covering the period 1980 to 2014 (Met Office, 2014 and 2015), as well as previous data presented in both the *Chesil Beach Investigation* (Babtie, 1997) and *Futurecoast* (Halcrow, 2002), the latter being based upon 10 years of UK Meteorological Office European Wave Model data for the period 1991 to 2000.

Further details are provided in Section 2.1 of **Appendix E**.

2.1.2 Extreme waves

Extreme waves can occur during storm events, with waves generated locally to the site and having relatively short wave periods. However, extreme wave events can also be generated far from the site by storms in the Atlantic Ocean, or possibly even as a result of tsunami generated by events distant from site. It is these more distant sources of extreme waves that cause long-period swell waves that are thought to have been the cause of previous large scale overtopping and overwashing events that affected Chesil Beach in the past. This differentiation between locally generated and swell waves also draws into focus the importance of improving the understanding of bi-modal wave characteristics along Chesil Beach, as discussed above in **Section 2.1.1**.

As part of this BMP update, new extreme wave heights analysis has been completed, using the most up-to-date wave climate record that includes the winter 2013/14 storm events. Details of this new analysis and the results, along with details of a number of previous studies have calculated offshore extreme wave heights for this part of the coast using a variety of data sets, are provided in Section 2.2 of **Appendix E**. However, for ease of reference the new analysis results are provided in **Table 2.1**, alongside the most recent extreme wave heights that represent current Environment Agency Guidance.

It should be noted that the highest recorded significant wave height recorded by the PCO Chesil Wave Buoy (refer to **Section 2.1.1**) on 14/02/2014 is 7.7m from a south-westerly direction. With reference to **Table 2.1**, this is equivalent to the 1:200 year (0.5% APO) extreme event calculated in 2012 for resultant waves from the south-west direction (current Environment Agency guidance), but is more like a 1:18 year event if using the south-west extreme wave heights assessed as part of new analysis.

Further details on extreme waves are provided in Section 2.2 of **Appendix E**.

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Table 2.1 *Extreme offshore significant wave heights calculated for Chesil Beach by previous studies*

		Offshore Significant Wave Height (m) by Return Period (1 in X years) [Annual Probability of Occurrence]							
Data Source		1 [100%]	10 [10%]	20 [5%]	50 [2%]	100 [1%]	200 [0.5%]	500 [0.2%]	1000 [0.1%]
Based on Met Office offshore swell wave hindcast between 1988 and 2008 for point 50.5°N 2.5°W (exact source unknown but cited in Royal Haskoning, 2009)		3.3	4.5	4.9	5.3	5.7	-	-	-
Resultant (wind+swell) waves for point gl2635 presented in Environment Agency South-West Flood Risk Assessment Wave Parameters data (Royal Haskoning, 2012) for three key wave direction sectors	South-East	4.2	4.6	4.7	4.8	4.8	4.8	4.9	4.9
	South	5.2	6.1	6.3	6.5	6.7	6.8	7.0	7.1
	South-West	6.3	7.1	7.2	7.4	7.6	7.7	7.8	7.9
Extreme waves (Hm0) calculated for this study assuming full wave climate (storm and swell waves) (refer to Section 2.2 of Appendix E)	All directions	4.8	6.8	7.3	8.1	8.8	9.4	10.2	10.9
	South-South-East	1.8	2.8	3.1	3.5	3.8	4.1	4.4	4.7
	South	3.0	4.1	4.5	5.0	5.3	5.7	6.2	6.6
	South-South-West	4.0	5.7	6.3	7.0	7.6	8.1	8.9	9.5
	South-West	4.7	6.7	8.1	8.7	9.1	9.4	10.2	10.8
	West-South-West	2.8	3.8	4.1	4.5	4.8	5.1	5.5	5.8

2.1.3 Winds

Historic wind data for the area is available for the same Met Office hindcast data point 365 covering the period 1980 to 2014 (Met Office, 2014 and 2015). **Figure 2.2** presents a wind rose of this data. From this it can be seen that the wind direction is much more variable than the wave direction (refer to **Section 2.1.1**) although the significant proportion of the wind comes from the south and west directions – so blowing onshore towards from the BMP area. The peak wind speed in this 34 years' of data is 24.5m/s and occurred during the storm of 14th/15th February 2014 from a south-westerly direction. This Met Office data has been used to calculate extreme wind speeds for the area and these values are presented in Table 2.2 (further details are provided in Section 2.3 of **Appendix E**). Based on this data, the wind speeds experienced from the south-west on 14th/15th February 2014 would have a return period of around 1:50 years.

Other wind records (in addition to the Met Office data) are available in the area, as follows:

- Portland Harbour meteorological observation station is operated as part of the South East Regional Coastal Monitoring Programme. This station is sited on the Weymouth and Portland National Sailing Academy (WPNSA) building and posts real-time data every 10 minutes to the channel coast website (http://www.channelcoast.org/data_management/real_time_data/charts/?chart=96&tab=met&start=1390176000&end=1392595200&disp_option=1&datum=chart) as well as provides an archive of records back to 1st December 2006.
- Wind records are recorded at Portland Port (at a point on the Portland Harbour Breakwaters) for Portland Harbour Authority by Richard Paul Russell Ltd. Very recent (and live) wind record data can be obtained by capturing it directly from the Portland Harbour Authority website at <http://www.weather-file.com/portland/>.

It should be noted that the WPNSA device is considered to not be an ideal site as there is some sheltering effect for the anemometer; although it is not that too bad and certainly clear to the south-west direction. Also, the wind readings from the WPNSA device are less than those measured by Portland Port (Personal communication, 2015). Further details on extreme waves are provided in Section 2.3 of **Appendix E**.

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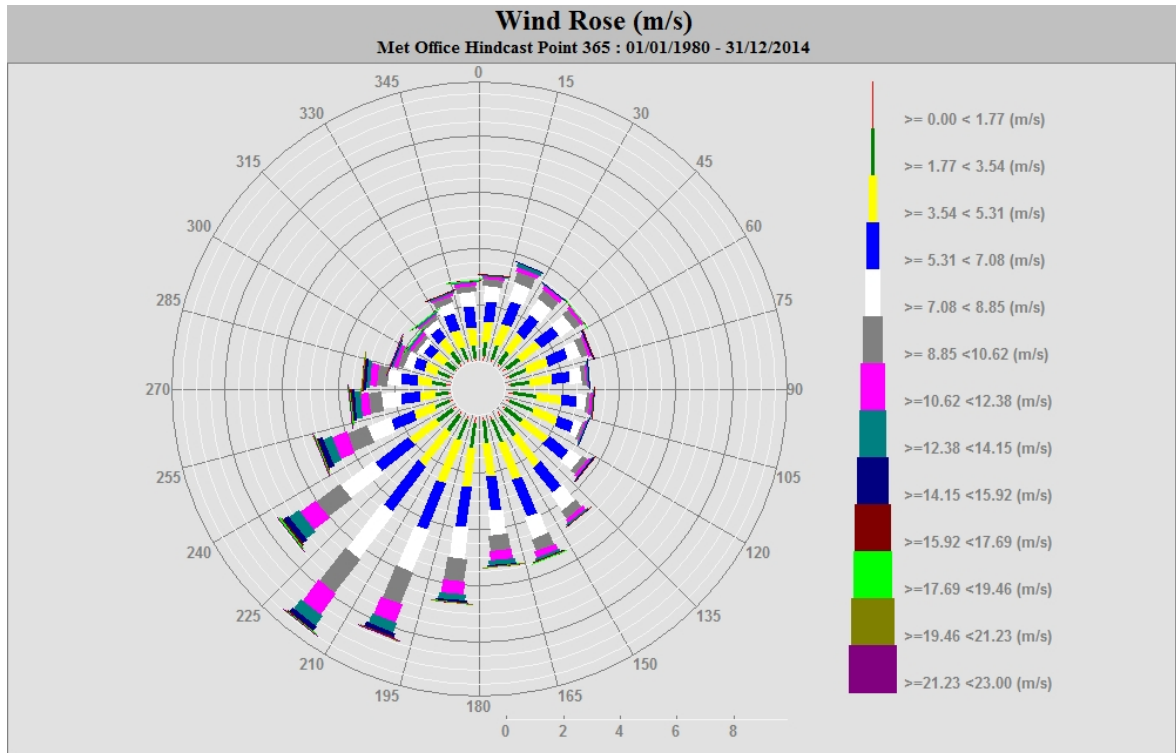


Figure 2.2 Wind rose from Met Office hindcast (Met Office, 2014 and 2015) for hindcast point 365 nearest to the BMP area based on Met Office model data covering the period 01/01/1980 to 31/12/2014. NB: Wind direction shown as direction wind comes from.

Table 2.2 Extreme wind speeds for Chesil based on Met Office data (refer to Section 2.3 of Appendix E).

Direction	Wind Speed (m/s) by Return Period (1 in X years)							
	1	10	20	50	100	200	500	1000
All directions	19.2	22.7	23.8	25.1	26.2	27.2	28.6	29.7
North	12.3	15.7	16.8	18.1	19.2	20.2	21.6	22.6
North-East	11.7	14.8	15.8	17.3	18.4	19.5	21.1	22.3
East	12.1	15.3	16.2	17.3	18.1	18.9	19.9	20.6
South-East	13.2	16.5	17.4	18.6	19.4	20.3	21.4	22.2
South	15.6	19.3	20.4	21.8	22.8	23.9	25.3	26.4
South-West	17.8	21.5	22.7	24.2	25.3	26.4	27.9	29.0
West	16.9	20.2	21.2	22.4	23.4	24.3	25.6	26.6
North-West	13.1	16.9	18.0	19.4	20.5	21.6	23.0	24.1

2.2 Water Level Climate

2.2.1 Tidal information

Tide levels for Chesil Cove are published in the Admiralty Tide Tables (ATT) produced by the UK Hydrographic Office (UKHO). Levels at this location are the most relevant for this BMP. The tide

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levels are provided in **Table 2.3** for this location. For completeness, levels for Portland on the eastern side of Chesil Beach and at Chesil Beach and West Bay to the west of the Chesil Cove site are also provided.

Table 2.3 *Tide Levels for Chesil Beach (UKHO, 2014).*

Tidal Condition	Tide Level (mOD)			
	West Bay	Chesil Beach	Chesil Cove	Portland
Highest Astronomical Tide (HAT)	2.3	2.3	2.3	1.6
Mean High Water Spring (MHWS)	1.9	1.8	1.9	1.2
Mean High Water Neap (MHWN)	0.8	0.8	0.7	0.5
Mean Sea Level (MSL)	0.1	0.2	0.2	0.1
Mean Low Water Neap (MLWN)	-0.6	-0.4	-0.4	-0.1
Mean Low Water Spring (MLWS)	-1.7	-1.3	-1.5	-0.8
Lowest Astronomical Tide (LAT)	-	-	-	-1.1

The tidal ranges at Portland, as stated in the ATT 2015 (UKHO, 2014), are as follows:

- Spring Tide Range = 2.0m
- Neap Tide Range = 0.6m

Historical information on tidal conditions at Weymouth (the nearest available site) from the National Tide and Sea Level Facility (NTSLF) network can be obtained through the British Oceanographic Data Centre (BODC) website (https://www.bodc.ac.uk/data/online_delivery/ntslf/).

The ATT is published each year and contains the tidal forecast for that year at the main Ports (Plymouth being stated in the ATT as the primary port for Chesil Cove in this case). However, tide forecasts up to 7 days into the future are available from the UKHO website (EasyTide) allowing the user to obtain the tide times for Chesil Cove (<http://www.ukho.gov.uk/easytide/EasyTide/index.aspx>).

Note that the levels in the ATT are in metres Chart Datum (mCD). To convert these levels to metres Ordnance Datum (mOD), the following values (as stated in the ATT (UKHO, 2014)) must be subtracted from the tide tables for the stated tide level location:

- West Bay = -2.25m;
- Chesil Beach = -2.10m;
- Chesil Cove = -2.10m (assumed value based on adjacent Chesil Beach as not actually stated in ATT); and
- Portland = -0.93m.

As there is no tide gauge recording carried out at Chesil Cove, the nearest tide gauge records to refer to in the future for either future studies or recording the conditions of a particular storm (refer to **Section 4.4**) are from the following active tide gauges located at:

- West Bay Harbour (data available online from http://www.channelcoast.org/data_management/real_time_data/charts/?chart=95);

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- Portland Port Q Pier (available from Environment Agency telemetry – see **Figure 4.2b** in **Section 4.4.2** below); and
- Weymouth Harbour (data available online from <http://www.ntsif.org/data/realtime?port=Weymouth>).

Further details are provided in Section 3.1 of **Appendix E**.

2.2.2 Extreme water levels

Extreme water levels have been calculated for Chesil Beach by a number of studies in the past. However, the most recent calculations, and the ones to be adopted for the BMP at this time are those provided in the Environment Agency's *Coastal Flood Boundary Conditions for UK Mainland and Islands* (Environment Agency, 2011a) for extreme water levels point 2380. These extreme water levels presented in **Table 2.4**. It should be noted that these extreme tide levels have been based upon interpolation of extreme water levels calculated for sites where there is adequate data for robust calculation. In this case the extreme tide levels have been derived by an interpolation of extremes between Exmouth and Portland and as a result are identified as having confidence intervals of between 0.1 and 0.3m, as indicated in **Table 2.4**.

Table 2.4 *Extreme Tide Levels for Chesil Beach (Environment Agency, 2011a).*

Return Period (1 in X years) [APO]	Extreme Water Level at Chesil (mOD)	Confidence Intervals (m)
1 [100%]	2.05	0.1
2 [50%]	2.12	0.1
5 [20%]	2.21	0.1
10 [10%]	2.28	0.1
20 [5%]	2.34	0.1
25 [4%]	2.36	0.1
50 [2%]	2.43	0.1
75 [1.3%]	2.46	0.1
100 [1%]	2.48	0.2
150 [0.7%]	2.52	0.2
200 [0.5%]	2.55	0.2
250 [0.4%]	2.57	0.2
300 [0.3%]	2.58	0.2
500 [0.2%]	2.64	0.2
1000 [0.1%]	2.69	0.3
10000 [0.01%]	2.89	0.3

2.3 Joint Probability Extreme Wave and Water Levels

Very little in the way of joint probability extreme wave and water level analysis appear to have been carried out for Chesil Beach. Prior to this BMP update, the most comprehensive analysis undertaken to derive a range of joint probability extreme wave and water level events for a number of return

period cases was undertaken in 2001 (Halcrow, 2001). That previous work is documented in the 2010 version of the BMP (Halcrow, 2010).

For this update of the BMP, new Joint Probability Analysis (JPA) of extreme waves (refer to **Section 2.1.2**) and water levels (refer to **Section 2.2.2**) has been undertaken. This new JPA is documented fully in Section 4 of **Appendix E**. However, for ease of reference, the outputs for the omni-directional waves case are presented graphically in **Figure 2.3**.

Further review and update of this data should be considered as part of the recommended detailed review of coastal processes understanding identified in **Section 1.4.4**.

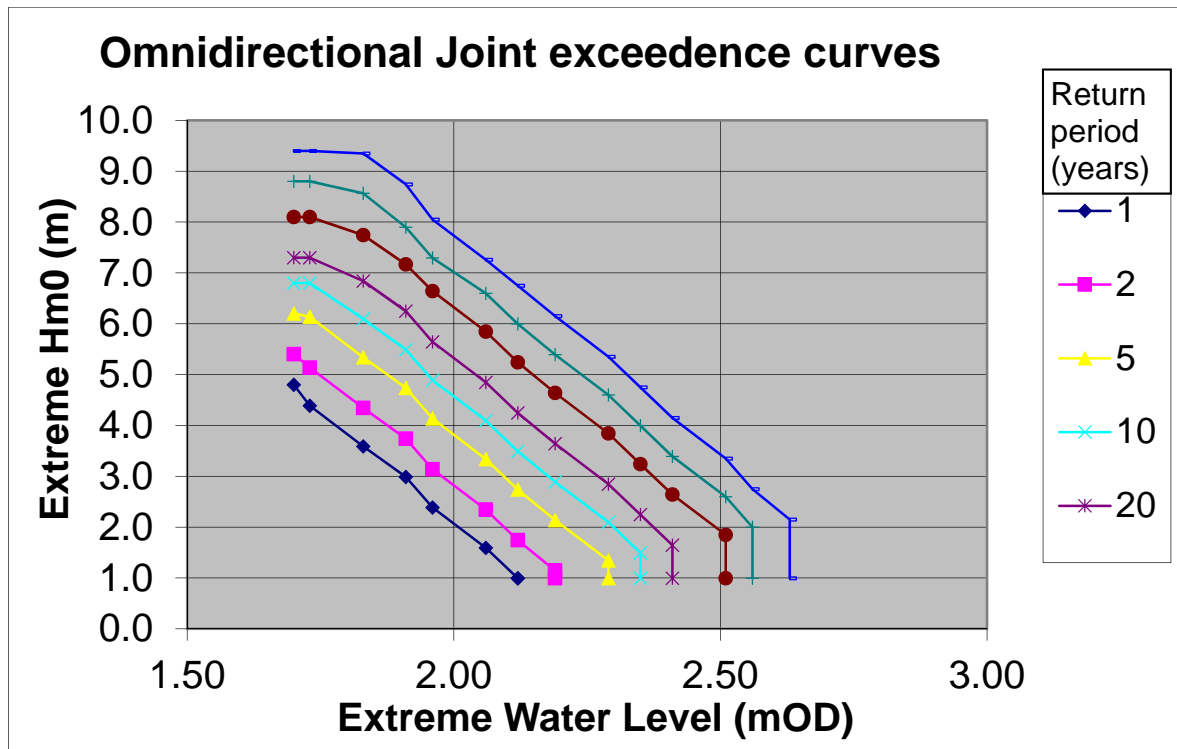


Figure 2.3 Plot showing Joint Probability Extreme Wave Height and Water Level curves for Chesil Beach for the omni-directional waves case (refer to Section 4 of Appendix E).

2.4 Climate Change & Risk

Information on the impacts of climate change is available from 'Advice for Flood and Coastal Erosion Risk Management Authorities' (Environment Agency, 2011b). This is the latest guidance and highlights that the main risk of climate change in relation to beach management is from sea level rise.

The guidance (Environment Agency, 2011b) suggests that predictions of the future rate of sea level rise for the UK coastline should be taken from UKCP09. Data downloaded from UKCP09 provides sea level rise from 1990. Anticipated rates of relative sea level rise and surge estimates over three time periods are presented in **Table 2.5**. The following estimates are presented in the table:

- Lower End Estimate: this is the low emissions scenario, 50% frequency, taken from the UKCP09 User Interface.

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- **Change Factor:** this is the medium emissions scenario, 95% frequency, taken from the UKCP09 User Interface.
- **Upper End Estimate:** these are generic values of sea level rise provided in the climate change guidance; they are 4mm (up to 2025), 7mm (2026 to 2050), 11mm (2051 to 2080), and 15mm (2081 to 2115).
- **H++ Scenario:** these are generic values of sea level rise provided in the climate change guidance; they are 6mm (up to 2025), 12.5mm (2026 to 2050), 24mm (2051 to 2080), and 33mm (2081 to 2115).
- **Upper End Estimate + Surge Estimate:** This is the upper end estimate plus the upper end surge estimate. The surge estimate are generic values provided in the climate change guidance; they are 20cm (up to the year 2020's), 35cm (up to the year 2050's), and 70cm (up to the year 2080's). With regard to the surge increase, the uncertainty with surge increase is even greater than for sea level rise.

The climate change guidance (Environment Agency, 2011b) recommends that in planning future coastal management options, the Change Factor (medium 95% frequency scenario) be used as the preferred scenario. All other scenarios are included to demonstrate the sensitivity of decision making through time, and can be used to refine the options to prepare for a wider range of future change.

Table 2.5 *Relative sea level rise estimates for Chesil Beach (see text above for explanation of terms used in this table).*

Time period	Various estimates of relative sea level rise and surge (mm/year)				
	Lower End Estimate	Change Factor	Upper End Estimate	H++ Scenario	Upper End Estimate + Surge Estimate
2011 to 2025	0.04	0.08	0.06	0.08	0.26
2011 to 2055	0.15	0.27	0.29	0.52	0.64
2011 to 2105	0.42	0.77	1.09	2.27	1.79

A number of previous studies have assessed the likely significant impacts of climate change upon Chesil Beach, most notably the SCOPAC *Preparing for the Impacts of Climate Change* report (Halcrow *et al*, 2001) and *Futurecoast* (Halcrow, 2002). These studies concluded that climate change is likely to result in changes to key forcing conditions, notably rising sea levels and changes in wave direction and wave height, and that such changes could have significant implications for physical conditions at the shoreline. For example, there could be increased risk of overtopping and overwashing of Chesil Beach if sea level rises and there is an increase in the frequency and size of storm events, with changes of 10% to 20% in longshore transport predicted to occur. Changes in wave direction of 1 or 2 degrees could also significantly alter shoreline sediment transport patterns by between 3% and 7%, with associated changes in wave focussing and patterns of erosion and accretion (Halcrow, 2002; Halcrow *et al*, 2001). Drift direction is especially important at Chiswell since

the Isle of Portland acts as a barrier to eastward transport so that increased transport in this direction would lead to beach accretion whereas increased westward drift would cause depletion of sediments.

2.5 Sediment Transport

2.5.1 Sediments

Chesil Beach is comprised of 98% chert and flint cobbles of varying size along the total length of the Chesil Barrier (Carr & Blackley, 1969). The grading of sediment increases along the length of Chesil Beach from west (D_{50} ~0.5cm) to east (D_{50} c~5cm) with a corresponding increase in beach face gradients (Babtie Dobbie, 1992). The largest cobbles along the barrier are located at this south-eastern part of Chesil Beach. Analysis of beach sediment size undertaken as part of the Chesil Beach Investigation (Babtie, 1997) found that the mean sediment size in this area was around 46mm, and that this had reduced compared to measurements made in 1969 that found the mean sediment size to be about 52mm.

Based on research utilising Ground Penetrating Radar (GPR) it is thought that the core of Chesil Beach consists of finer grained material (Bennett *et al*, 2009). There is, however, insufficient data on the composition of Chesil Beach throughout its structure and how this varies spatially along its length. This is important to understand as the composition affects porosity and permeability of the beach which in turn is an important factor in how the beach performs as a sea defence.

Recent research in 2015 by the University of Loughborough, using photogrammetry techniques, has assessed the spatial variation in beach surface sediment grading along Chesil Beach between Beach Profiles 6a00109 and 6a00172 within the BMP extent (refer to **Section 4.1** for profile locations). This found that there is an initial rapid decrease in grain size with distance away from Chesil Cove, the rate of which gradually slows (**Figure 2.4**). It is also apparent that there is a substantially greater longshore variability within the southern part of the beach that was subject to remedial work during and after the winter 2013/2014 storms. That said, the analysis also showed that all samples taken along the beach are classified as very-well sorted, and that there is no appreciable step in grain size between the modified (MU 1 and MU2) and unmodified (MU3) parts of the beach. These findings led the research to conclude that “there is little evidence that the beach management interventions undertaken during 2014 have had a significant impact on the grain-size structure of the beach” (Graham & Rice, 2015).

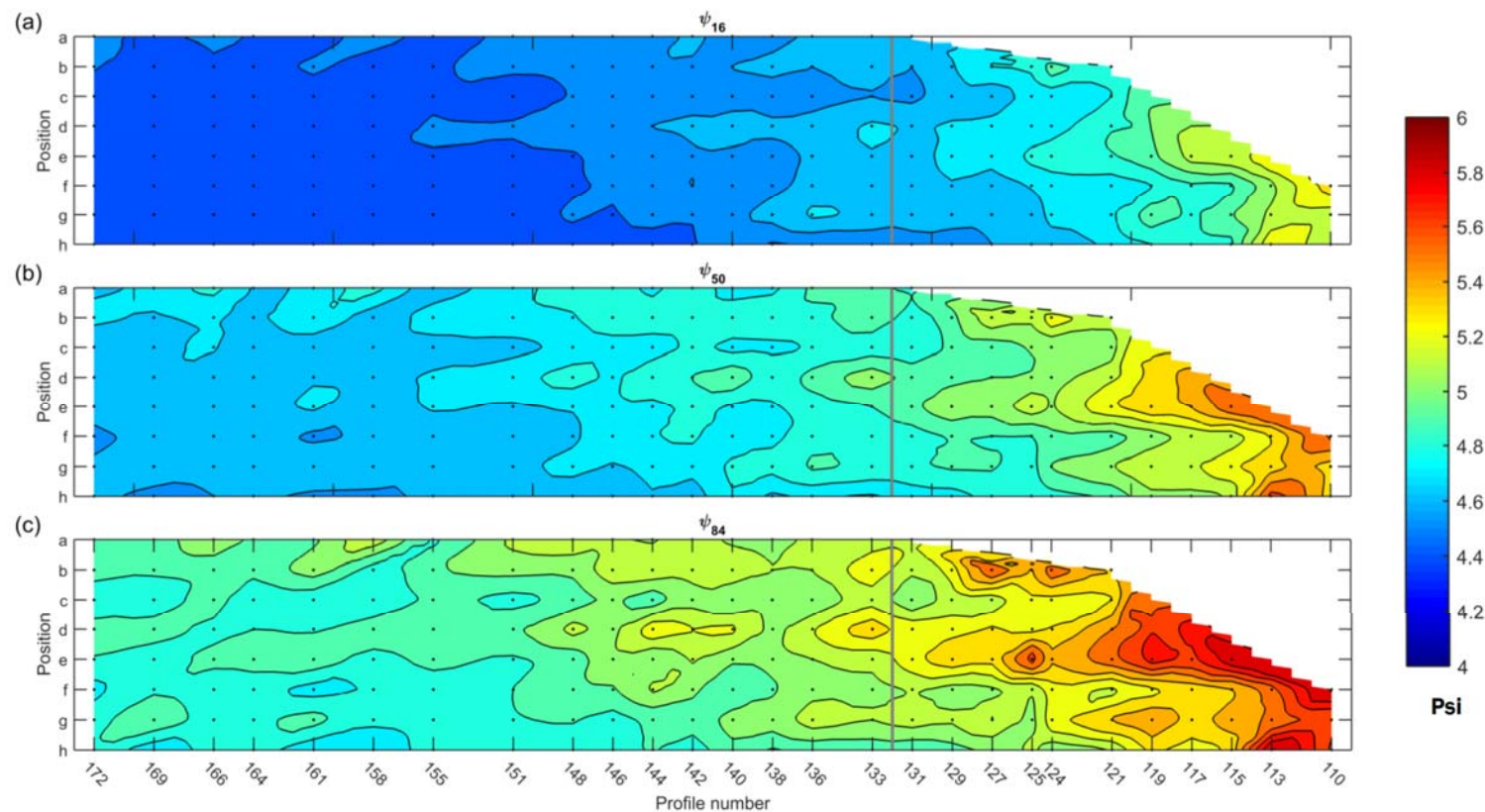


Figure 2.4 “Isopleth map of spatial variability in key grain-size percentiles for the entire surveyed area, as measured by photographic sampling. The horizontal axis indicates position along the beach, with reference to the transverse profile numbers (which are ordered as if looking onshore). The vertical axis indicates the morphological position on the beach. Note that the horizontal and vertical axes mark relative positions and are not to scale. The vertical heavy grey line marks the boundary between the area subject to remedial works during 2014 (profiles 109-131) and the unmodified part of the beach. Dots indicate sampling positions. (a) ψ_{16} . (b) ψ_{50} . (c) ψ_{84} ”(from Graham & Rice, 2015).

2.5.2 Sediment transport mechanisms

The Chesil Barrier is directly exposed to dominant south-westerly Atlantic waves between a 'window' of 215° to 240° that is delimited by Start Point and the north-western coast of Brittany, France (Bray *et al*, 2004). The exposure to south-westerly waves reduces towards the west as the influence of Start Point on waves propagating into Lyme Bay increases in this direction. The beach is also exposed to waves from the south and south-southeast, although these are less frequent and are less energetic, being fetch limited by the width of the English Channel.

The dominant south-west waves have resulted in the well-defined sediment grading (increasing shingle size from west to east) along the Chesil Barrier that is observed above the low water mark (below the low water mark the sediment grading is generally coarser and less well sorted (Bray *et al*, 2004)). Due to this wave climate, a finely balanced drift regime with a low rate of net shingle transport from west to east has been established over thousands of years, with the energy provided by these conditions being sufficient to transport the large shingle sizes towards Portland. Periodic exposure to waves from the south and south-easterly direction result in a drift reversal, with net transport to the west, but under these conditions the smaller sized shingle is moved preferentially. The result is that total drift along the beach in each direction is significant, but subject to frequent reversals so that net drift is small by comparison and alters in magnitude and often direction each year.

The long-term exposure to this transport regime is thought to be the reason for the Chesil Barrier's present smooth swash-aligned plan-form, whilst its great height (the crest height of the barrier increases from +6.0mOD in the west to about +14.0mOD at Portland) relates to the exposure of the beach to waves that cause material to be pushed up the beach, so building the crest. The near-normal orientation of this shoreline, relative to the predominant wave direction does mean, however that the sediment transport regime along the length of Chesil Beach is very sensitive to the direction of onshore waves, with even small changes in the wave direction potential resulting in drift reversals that affect local patterns of accretion and erosion (Halcrow, 2002).

Whilst wave driven long-shore transport is important to the grading and maintenance of the plan form of Chesil Beach, it is the response of the beach to large swell and locally generated wave events that is responsible for the long-term gradual roll-back of the feature towards the land.

The morphology along the eastern-most part of Chesil Beach, within which the extent of this BMP lies, operates in a dynamic equilibrium with major storms producing profile changes and 'normal' energy conditions that follow, allowing the recovery of the beach. The overall effect of these processes means that the beach retains its morphological form within a constantly varying envelope of beach geometry whilst undergoing slow landward migration.

There appear to be two types of storm conditions that affect Chesil Beach. The majority of storms are deep depressions approaching from the south-west where the combination of strong winds and low barometric pressure can produce storm surges in the English Channel combined with high local waves. A rarer type, but potentially more dramatic in impact, occurs when large storms out in the Atlantic generate huge, long-period swell waves that travel up the Channel and impact the beach. Such waves can have a period of up to 20 seconds, compared with the 5-10 second period of locally generated waves. Two such events are known to have occurred in 1904 and 1979 (Chesil Beach website (a)).

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Research by the University of Portsmouth (Bray & Sandercock, 2007) suggests that the process by which adjustment of the beach profile occurs differs depending upon the type of wave event:

- Annual storms where swash just reaches the crest can cause berm deposition on the crest and have the potential to build its width and elevation (overtopping);
- Strong locally generated waves can saturate the beach face and cause seaward drawdown of shingle resulting in cause cut-back of the beach crest, causing the narrowing of the crest that eventually can cut through the width of the crest and allow waves to overwash the beach;
- Large swell waves cause direct overwashing of the crest (i.e. the waves simply run-up over the beach crest) and thereafter transport shingle landward and lowers the crest.

These mechanisms are consistent with observations from other barriers and spits, both in the field and when subject to simulated storms in the laboratory (Defra/EA, 2008). **Figure 2.5** from Bray & Sandercock (2007) illustrates these processes. With reference to this figure, and the record of past events in **Section 1.3.2**, it is believed that the storms of winter 2013/14 caused the beach along parts of the BMP area to reach a position between the “overtopping” and “overwashing” states, whilst the event of November 1824 resulted in the beach reaching the “overwashing and crest lowering” state.

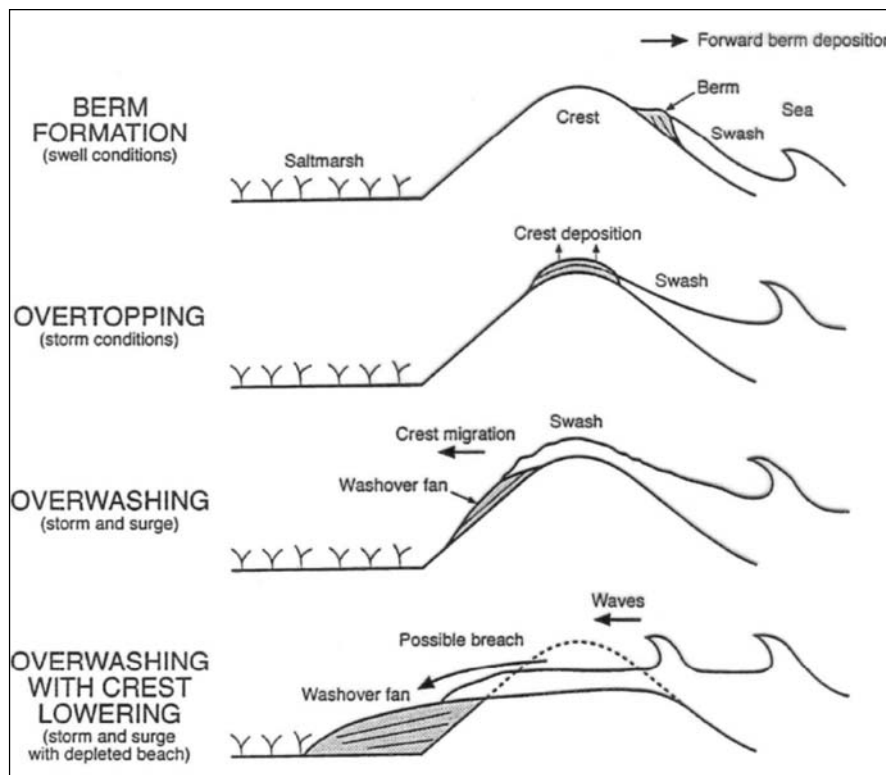


Figure 2.5 *Diagram showing the mechanisms by which barrier beaches evolve (from Bray & Sandercock, 2007).*

The SCOPAC *Sediment Transport Study* (Bray *et al*, 2004) suggests that the section of Chesil Beach at the eastern end between Wyke Regis and Chiswell is one of the most sensitive parts of the Chesil Barrier to changes during storm events. This susceptibility may in part be due to the focussing of swell waves on this area caused by the refraction and diffraction of waves as they pass over irregularities in the offshore seabed of Lyme Bay (Babtie, 1997; Halcrow, 2002). The areas where

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wave focussing occurs also happen to be the most volatile parts of the beach, having exhibited the greatest variability in beach profile over the length of available observations. The construction of sea defences at Chiswell in the 1980's and 1990's has served to artificially stabilise the beach crest in this area.

By way of summary of sediment transport processes along Chesil Beach, **Figure 2.6** graphically illustrates the processes discussed above. This figure was produced as part of the SCOPAC *Sediment Transport Study* (Bray *et al*, 2004). This is currently being reviewed and an update is expected to be published in 2016.

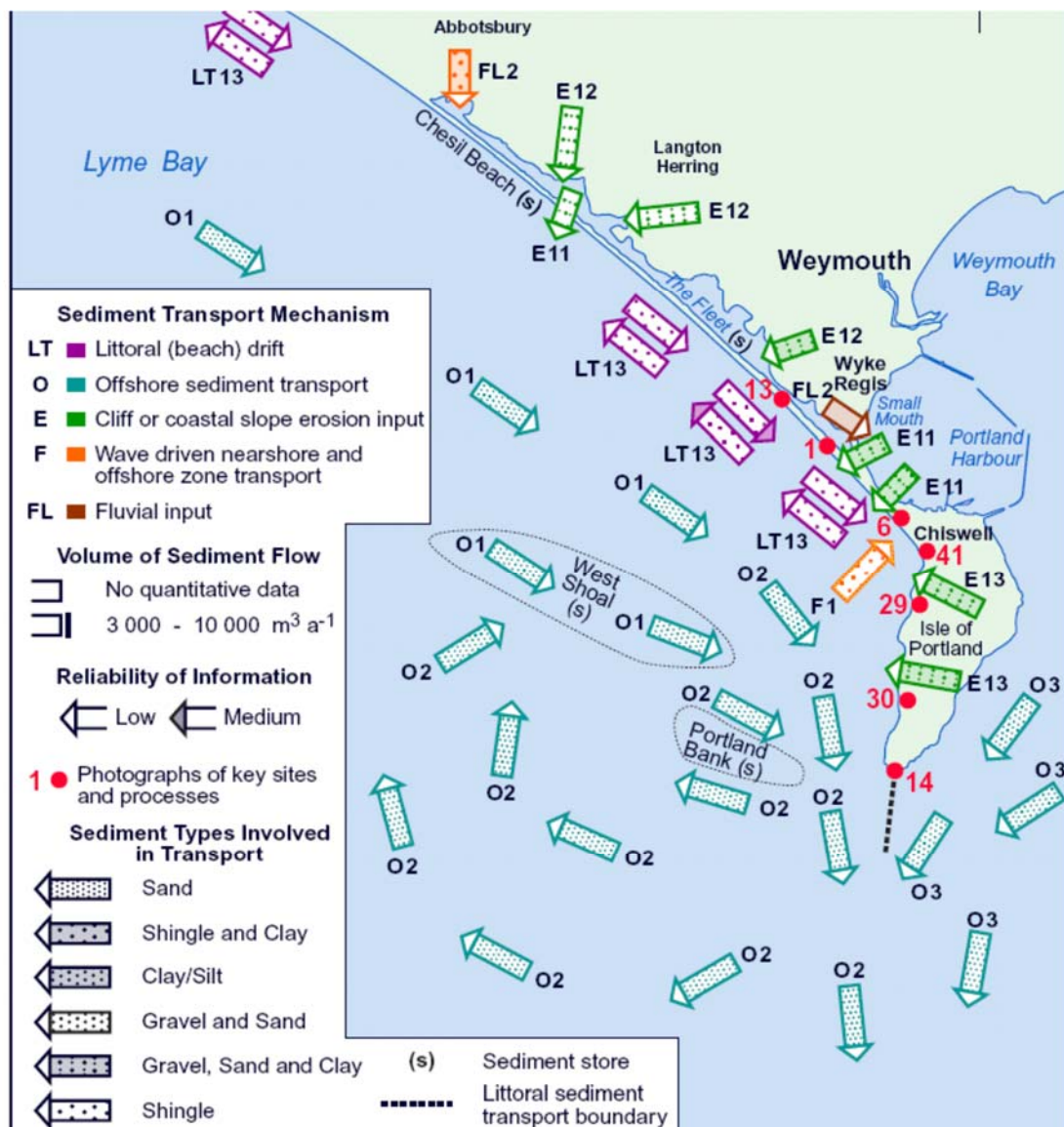


Figure 2.6 *Illustration summarising sediment transport processes in the area of this BMP (from Bray *et al*, 2004).*

Further information is provided in Section 6.2 of **Appendix E**.

2.6 Shoreline Movement

2.6.1 Overview of the evolution of this shoreline

The following provides an overview of how the shoreline has evolved to its present state, providing context for the processes that are observed to be occurring along the beach and which need to be considered when taking future flood risk management decisions for the section of coast covered by the BMP.

The coastline of Lyme Bay, which extends between Start Point in the west and Portland Bill in the east, has been retreating and changing in orientation over the last few thousand years in response to the large scale drowning of the English Channel, following the last ice age (c.14, 000 years Before Present (BP)). Prior to this period of rapid sea level rise, sea levels were 100 to 120m lower than present, and it is possible that there was a prototype continuous 'super' barrier between what is now Portland Bill and Start Point (Bray *et al*, 2004; Bray, 2007).

The formation of Chesil Beach has been much discussed over the years and is still the subject of continuing debate. Continuing research yields further insights into the origin of the material that forms the beach and how it was transported to its current location. The most widely accepted theory is that Chesil Beach initially formed from predominantly sandy deposits in Lyme Bay as water levels rose rapidly at the end of the last ice age 14,000-20,000 years ago. These deposits were eroded and the sand and gravel driven onshore to form barriers of non-cohesive sediment that inundated low-lying river valleys. As the barrier beaches were driven further east by rising sea levels they overrode existing sediments and the Fleet was formed starting about 7,000 years ago. The formation of the Fleet was virtually complete by 5,000 years ago (Bray *et al*, 2004; Chesil Beach website (b)).

As sea level began to stabilise about 4,000-5,000 years ago, Chesil Beach stood close to its present position although it has continued to migrate landwards but at a more gradual rate. Current estimates suggest that at the southern end the rate of advance is greater than the rate of advance further north towards West Bay. This advance occurs under storm conditions and is caused primarily by over-topping waves and to an extent by 'cann' action, where the water comes through the beach pushing quantities of pebbles out into the Fleet (Chesil Beach website (a)).

When it first formed in about its current position, Chesil Beach was predominantly sandy with layers of shell and coarser material indicating over-washing by the sea. At this time relict landslides in West Dorset and East Devon, left stranded by falling sea levels during the ice age, were re-activated and the combination of re-working of extensive debris aprons and erosion of existing cliffs yielded large quantities of gravel. The present Chesil Beach consists of 98% flint and chert and is very similar in composition to sediments found further west towards Branscombe. Estimates suggest that as much as 60 million cubic metres of gravel could have been supplied from this source. This material was transported to Chesil Beach by longshore drift via a series of pocket beaches (Bray *et al*, 2004; Carr & Blackley, 1969; Chesil Beach website (b)).

Along central and western parts of Lyme Bay, in areas where the barrier beaches have become pushed against the former cliff line, headlands have emerged resulting in segmentation of the beach into a number of smaller sections, separated by headlands composed of more resistant rocks. The headlands now intercept littoral drift so there is little contemporary shingle transfer between beaches. Those remaining eastwards of Seatown are considered to be largely relict features. Past beach mining has depleted the beaches to the west of West Bay and together with the effects of coastal

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recession has further increased prominence of the headlands. In combination with the jetties/breakwaters at West Bay this has cut off the supply of material to Chesil Beach from the west. Chesil Beach must now be regarded as a closed shingle system with no significant gravel replenishment from outside sources. It is therefore sensitive to environmental changes such as rising sea levels and potentially sensitive to human interference Bray *et al*, 2004; Chesil Beach website (b)).

The present day Chesil Beach is a linear shingle storm beach stretching from Portland in the south to West Bay in the north-west. At its widest it is up to 200m in width. The height of the free-standing portion of the beach varies between 10.5m and 14m above mean sea level and typically increases eastward from Abbotsbury (11m) to Chiswell (14m).

The seaward face of the beach is steeply shelving and this continues below the sea level until it gradually levels off at around 18m below sea level some 300m offshore in the southern part of the beach. Further north (towards West Bay) the offshore depth is around 11 metres (Chesil Beach website (a)). The section of coast between Wyke Narrows and Chesil Cove, within which the extent of the Chesil BMP lies, covers the easternmost end of the 13km 'detached' or 'free-standing' part of Chesil Beach between the Isle of Portland and Abbotsbury. The majority of this length is backed by the Fleet lagoon. The crest height and sediment size of Chesil Beach are greatest at this Portland end of Chesil Beach, with large shingle pebbles and crest heights of up to +15.0mOD.

The Fleet Lagoon that runs along the landward side of Chesil Beach is a tidal saline lagoon that is connected to the sea by a culverted tidal entrance into Portland Harbour at Ferrybridge. During high tidal levels in Lyme Bay water can seep through the beach and into the Fleet Lagoon, but otherwise there is no significant direct interaction between the Fleet and coastal processes from the seaward side of Chesil Beach. At Wyke Narrows the tidal flow is constrained such that high currents flow through this channel that are sufficient to keep the channel open (and so stop the beach from rolling back and cutting off the Fleet from the open sea). Intrusion of saltwater occurs both through the tidal exchange with Portland Harbour, as well as through gradual seepage through the shingle barrier and (less frequent) 'bursts' of salt water from the barrier that form 'cann's' on the Fleet side of Chesil Beach (Bray & Sandercock, 2007).

Over the past century there has been a very slow rate of retreat of the Chesil Barrier, with *Futurecoast* (Halcrow, 2002) suggesting the beach has retreated at a rate of about 0.10m/year. The SCOPAC *Sediment Transport Study* (Bray *et al*, 2004) also provides analysis of the movement of Chesil Beach, and suggests that between 1853 and 1993 the crest position of the beach section between Wyke Regis and Chiswell has retreated by between 8m to 17m (although less retreat occurred at Chiswell due to the stabilising effects of defences and works undertaken to restore the crest following overwashing). Comparison of beach profiles at Ferrybridge suggest that further recession of up to 6m has occurred from 1990 to 2006, although that study did not extend any further south east towards Chiswell (Bray & Sandercock, 2007).

It would therefore be useful to compare recent Chiswell profiles measured by the Plymouth Coastal Observatory with earlier ones from the 1997 Babbie study (Babbie, 1997) and Carr and Seaward (1991). Crest elevation has also varied tending to reduce by up to 2m at Chiswell over the interval 1853 to 1969 with up to 0.5m of additional loss from 1969 to 1990 (Carr, 1996). Some restoration has been achieved close to Chiswell where gabion construction has elevated and stabilised the crest.

Although recession is expressed as an annual rate it occurs intermittently during major overwashing events. Thus, there can be extended intervals between events where recession is negligible followed by recession of several metres within a few hours during a major event. Overall, the SCOPAC (Bray *et al*, 2004) analysis suggests an annual average recession rate for this section of Chesil Beach of between 0.06m/year to 0.12m/year, which is in agreement with the analysis produced by *Futurecoast* (Halcrow, 2002). It should be noted, however, that there is insufficient accurate data available at the present time to derive conclusive long-term trends and recession rates and so these rates should be treated with caution. This can be reviewed as more data becomes available.

Further details about the evolution of the BMP area and the wider Chesil Beach are provided in Section 7.1 of **Appendix E**.

2.6.2 Beach cross-sectional areas

The beach profile survey data covering the BMP area collected since 2007 as part of the SWRCMP (refer to **Section 4.1.1**) is used to calculate cross-sectional area changes over time. This analysis is presented in **Figure 2.7**. These values are calculated over the beach ridge down to approximately the -1.0mAOD level.

From the data presented in **Figure 2.7**, it is evident that the beach has stayed fairly stable with only small seasonal and storm driven fluctuations fluctuated over the period between 2007 and 2014/15. The exception is the marked erosion in winter 2013/2014 as a result of a sequence of large storm events. Since the winter 2013/2014 storms, the cross-sectional areas have generally shown a trend for recovery back towards pre-storm levels particularly in the north-westernmost part of the area covered (profiles 6a00138 to 6a00148). Cross-sectional areas in the south-eastern part of the area covered (6a00118 to 6a00131) are still between 80m²-130m² below the pre-2014 storm levels as of the most recent survey available, the date of which varies along the frontage.

Further analysis of beach cross-sectional area is provided in Section 7.2 of **Appendix E**.

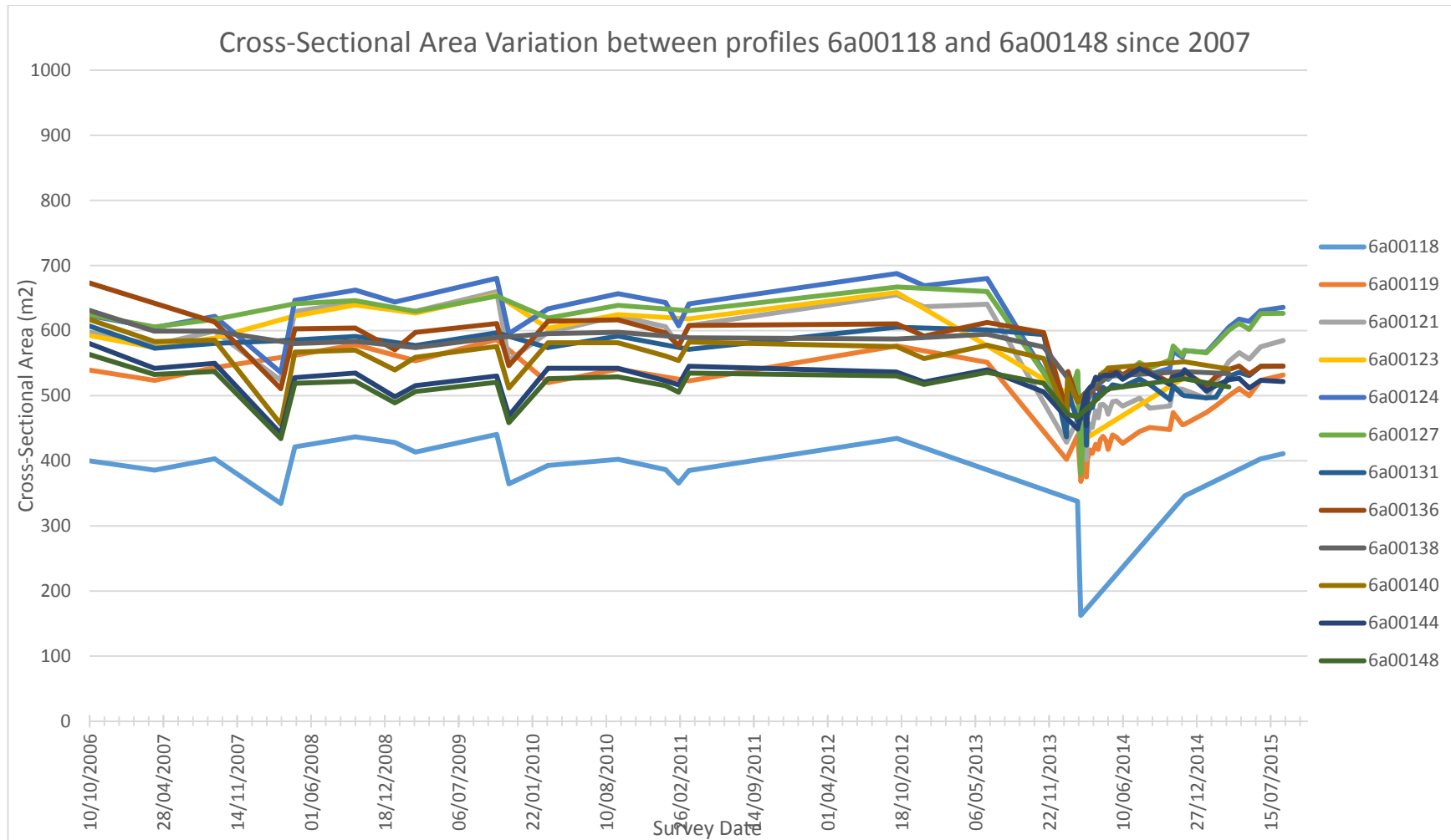


Figure 2.7 Graph showing the changes in cross-sectional area along each profile over time, between April 2007 and August 2015. NB: refer to Section 4.1.1 for beach profile locations.

2.6.3 Beach volumes

Estimates of the volume of material within Chesil Beach vary between 15million and 65million cubic metres. The uncertainty in the exact volume is due to difficulties in assessing precisely where the actual bed level beneath Chesil Beach lies (Defra/EA, 2008). In developing this BMP update, the PCO beach profile data along with additional beach profile data collected by the Environment Agency in 2014 (following the winter 2013/14 storms), has been analysed using CH2M HILL's SANDS software (the same software used by PCO for this purpose that integrates beach volume between two cross-shore beach profile locations). In undertaking this analysis, a 'Master Profile' has been defined that covers the whole beach area, as illustrated in **Figure 2.8**. This 'Master Profile' provides to defined fixed datum against which beach volume changes can be monitored over time. This is the best available approach to monitoring volume changes and it is unlikely that any improvement could be really made unless the bed levels beneath Chesil Beach can be accurately defined in the future (refer to **Section 4.1.2**).

Figure 2.9a shows how the volume of beach material between pairs of profile lines has altered along the beach since 2007 using the defined 'master profile' described above. From this the following observations can be made:

- For most of the period since 2007, the volume of beach material between each pair of profiles has been largely static with very minor fluctuations, indicating the beach for most of the period has been stable.
- The most marked and rapid change in volume in the data is as a result of the winter 2013/14 storms when there is a clear loss of volume (to varying amounts) evident along most of the area covered by profile data. Most locations then show a gradual recovery of volume following the winter of 2014 (NB: further discussion of this is provided in **Section 2.6.4** and Section 7.4 of **Appendix E**).

Figure 2.9b shows the cumulative volume change for profiles within MU1 and MU2. From this it is evident that:

- For these two managed units along the BMP frontage, the total volume between April 2007 and December 2013 (i.e. pre-winter 2013/14 storms) was approximately 500,000m³ (split between MU1 with ~160,000m³ and MU2 with ~340,000m³).
- The volume reduction due to the winter 2013/14 storms was greatest in MU2 with a reduction of about 200,000m³, compared to about 90,000m³ reduction in MU1.
- Both MU1 and MU2 show gradual recovery over the period from March 2014 to August 2015, but volumes in August 2015 are still below the typical pre-winter 2013/14 storm levels.

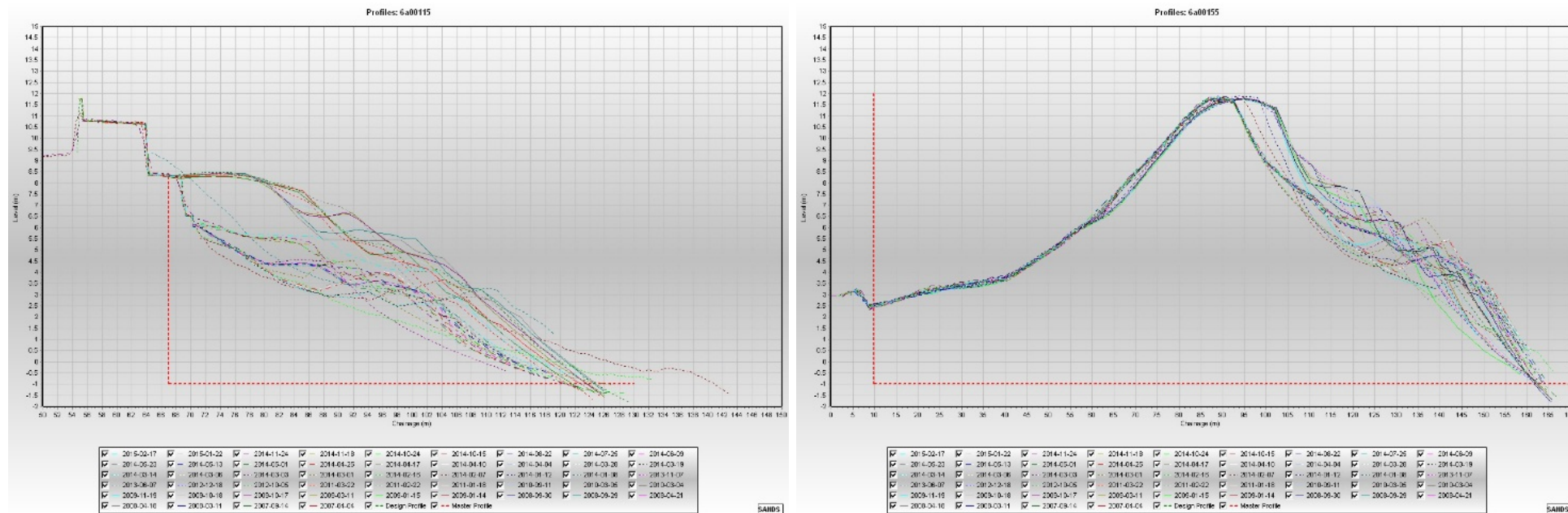


Figure 2.8 Examples of beach profile data with 'master profiles' shown along the BMP frontage.

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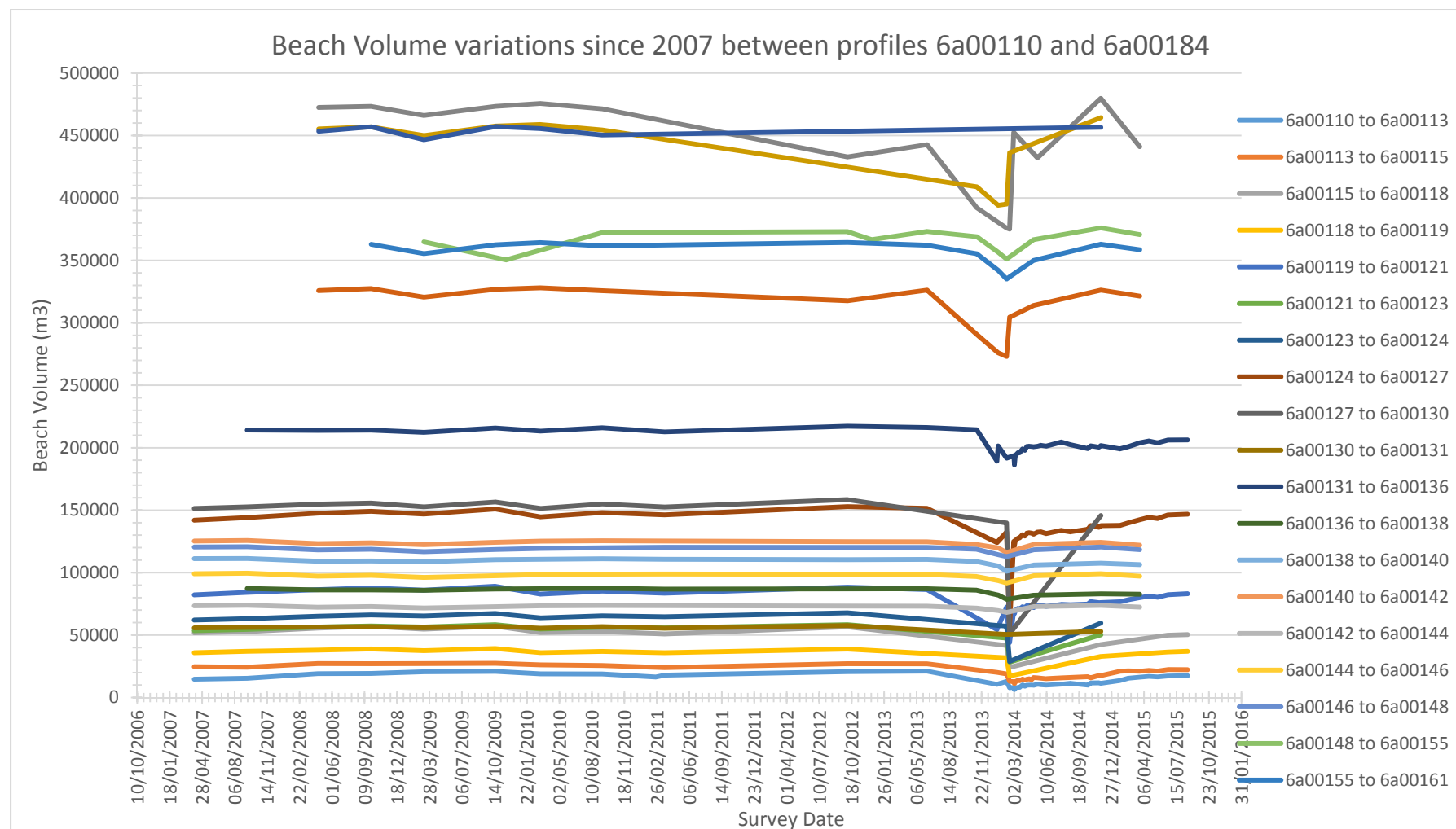


Figure 2.9a Changes in beach volumes between surveys from 2007 onwards using data collected by Plymouth Coastal Observatory and the Environment Agency. NB: refer to Section 4.1.1 for beach profile locations.

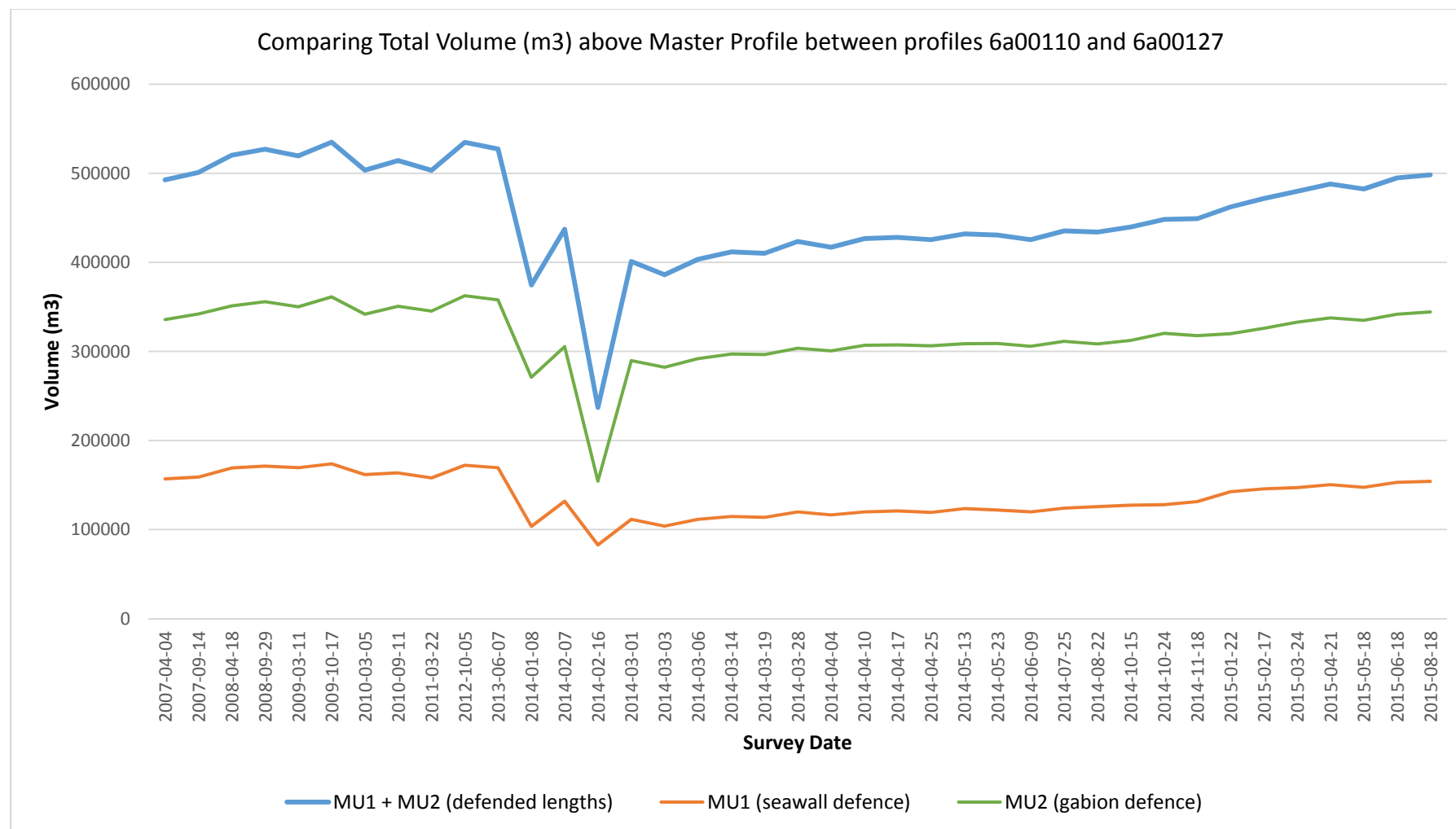


Figure 2.9b Changes in beach volume between surveys from 2007 onwards along MU1 and MU2. NB: refer to Section 4.1.1 for beach profile locations.

2.6.4 Beach profile storm response

The key mechanism for significant movement of sediment along the beach is wave action during significant wave events. As discussed in sections above, these wave events can take a number of forms, but can be primarily considered as swell waves and locally generated waves.

Swell waves from the Atlantic cause the most damage through overtopping of the beach. These waves appear to be affected by the features on the seabed far offshore, including an offshore mound affecting the wave approach. Refraction and diffraction of waves as they approach the shoreline in Lyme Bay therefore appears to be an important factor with swell waves. Swell waves can strike the beach segment between Chiswell and West Bexington directly without diffraction. However, Start Point blocks direct arrival of swell waves to the west of West Bexington so that only diffracted swell waves are significant there. Refraction appears to be very important according to the results of the *Chesil Beach Investigation* (Babtie, 1997) that found swell waves were extremely sensitive to the bathymetry of Lyme Bay where features in water depths of up to 50m could affect transformation processes (shoaling and refraction) as the waves travel inshore. A depression and mound located well offshore on the bed of Lyme Bay appear to focus the waves upon specific sections of the coastline at Portland Bill, Wyke Regis and Abbotsbury (the long wavelength gives an elliptical motion providing more horizontal energy, leading to the construction of a series of banks associated with high water). These long swell waves are both constructive, building up the crest by the process of overtopping, and destructive as they can saturate the beach face and the backwash generated can draw shingle seaward. Furthermore, extreme swell waves can overwash, lower the crest and push large quantities of shingle landward as overwash deposits, forming the long slope to the back of the beach behind the crest.

Locally generated waves lead to percolation through the beach until it fluidises, creating “cans” on the eastern side of the beach where the percolation occurs. Short locally generated waves are destructive cutting down the mid-beach. The circular motion of the wave causes the waves to break in to the beach at an angle with a net downward movement of energy, hence giving a weaker swash than backwash and moving material down the beach. This stronger backwash is thought to be affected by the infiltration capacity of the beach which, when exceeded, results in all of the swash being returned in a seaward flow as it is unable to infiltrate the beach. This would be in line with findings of recent research by Masselink *et al* (2009) that suggests changes in water level within the beach influences swash and backwash characteristics. When a fully developed backwash meets a forming swash, shingle is dislodged due to the turbulence of the mixing, leaving the bank at the angle of repose of the material. This can also be followed by overtopping waves sometimes with locally generated waves being carried on top of an underlying swell (bimodal wave condition). Following storms, the material is normally returned to the beach at spring tides. These storms occur approximately twice yearly, but occur on a spring tide approximately every 5 years (Environment Agency, 2009a). However, there is limited historical data available to relate conditions at the site and associated beach response and flood risk for many of the past events that have impacted Chiswell, with the exception being the events that impacted the area over the winter of 2013/14 (refer to **Sections 1.3.2, 1.3.3, 4.4.2 and Appendix M**).

Often extreme tides and waves occur together as low pressure systems. These generate storm wave (swell and wind waves) and surge events that combine to cause extreme tide levels. During an event the beach will re-profile, leading to greater run-up for waves. From the piezometer recordings on the

beach (recorded by the Environment Agency), it takes approximately 2 hours from high water to maximum piezometric levels in the beach. This is due to the presence of a sand/silt matrix at the lower levels of the beach – at higher piezometric pressures this becomes mobile, causing the permeability to resemble that of shingle (Environment Agency, 2009). It has also been postulated that Chesil could be exposed to tsunami type events generated from seabed earthquakes or submarine landslides in the Atlantic that travel up the English Channel (several events recorded with wave heights of 2m to 9m in an otherwise calm sea with periods of up to 10 minutes) (Bray *et al*, 2004), although such events could equally be the result of swell waves and imprecise historical reporting.

Since the beginning of the routine collection of beach profile data in 2007 by PCO, there have been seven storm events for which a post-storm survey has been called-out as part of the SWRCMP. Section 7.4 of **Appendix E** provides details of the impacts of these and other past storm events.

2.6.5 Predictions of future shoreline movement

Futurecoast (Halcrow, 2002) predicted that overwash of Chesil Beach along the natural undefended part of this section of coast would occur during storm and swell wave events, leading to the roll-over of the beach into the Fleet lagoon. Eventually this could cause the barrier to become attached to the mainland at Wyke Narrows, thus enclosing the Fleet and cutting off its tidal exchange with the open sea at Portland Harbour and causing the segmentation of the Chesil Barrier. It is very uncertain as to when this would occur, although it would likely be the result of a very large event of a scale similar to that of November 1824. That event caused around 80 houses to be destroyed with the loss of 26 lives at Chiswell, the ferry house at Small Mouth to be destroyed with the loss of 2 lives, and further to the north-west of the BMP area, the destruction of the village of East Fleet as a ‘tidal wave’ broke over Chesil Beach (Environment Agency, 2009a; West, 2005).

Futurecoast (Halcrow, 2002) also predicted that the continued presence of defences at Chiswell would tend to prevent a breach of the barrier in that specific area. However, this could lead to a discontinuity in the beach plan form as the unprotected beach to the west (towards Wyke Narrows and westwards) rolls-back during storm events. This in turn would increase the exposure of the Chiswell section of the beach to wave attack.

Regarding the potential for future shoreline movement along Chesil Beach, a simplified method that relates historic recession rates and historic sea level rise to future sea level rise has been used to derive upper and lower estimates of potential future movement of the beach crest over the next 100 years. Details of this analysis, which updates work done in developing the 2010 version of this BMP, are presented in Section 7.5 of **Appendix E** whilst the results showing the range of future recession rates and beach crest movement predicted to occur using this method are summarised in **Table 2.6**. **Figure 2.10** shows how the 100 year upper and lower estimates of beach recession stated in **Table 2.6**, in terms of beach crest position, could impact upon the land currently behind Chesil Beach, particularly the A354 Portland Beach Road that provides the only highway access to Portland and services and utilities that run beneath the road and Chesil Beach to serve the communities on Portland.

It should be noted that the predictions of shoreline retreat presented in this section assume a linear retreat pattern controlled by sea level rise. In reality, the retreat of the beach is likely to be as a result of storm events causing overtopping and overwashing of the beach crest, as occurred as a result of

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the winter 2013/14 storms (refer to **Section 2.6.4**), or even breaching of the beach followed by a period of re-building in a more eastwards position as is believed to have occurred in the 1824 event (refer to **Section 1.3.2**). Events such as these only occur occasionally and so the beach is likely to be more or less 'stationary' in one position in periods between large storm events.

Table 2.6 *Upper and Lower estimates of future beach recession over the next 100 years.*

Prediction period	Retreat Rate (m/year) by end of period		Total Recession over period (m)	
	Low Estimate	High Estimate	Low Estimate	High Estimate
2009 (baseline)	0.06	0.12	-	-
2009 to 2025	0.14	0.35	2	6
2025 to 2055	0.17	0.58	5	17
2055 to 2115	0.20	0.92	12	55
TOTAL	-	-	19	78

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Figure 2.10 Upper and lower estimate of future beach crest recession over the next 100 years.

2.7 Percolation through the Beach

Whilst overtopping and overwashing of the beach during storm events, as discussed in the above sections, are two significant causes of flood risk, a further significant risk is presented by percolation of water through the beach. This occurs as a result of a combination of high tide levels and large waves that force seawater through the beach, and is associated with (i) regular seepage that occurs during high spring tides and (ii) enhanced seepage or springs or even 'bursts' of seawater forming 'canns' on the eastern side of the barrier (Halcrow *et al*, 2001; Bray & Sandercock, 2007). It should also be noted that these saline seepages are also sub-features of the Chesil and the Fleet SAC (refer to **Section 2.8.4**).

Within BMP MU1 and MU2, water percolating through the beach from Lyme Bay is prevented from forming 'canns' by virtue of it being diverted into an interceptor culvert constructed in the 1980's beneath the seawall and gabion mattress as part of the Chiswell Sea Defence Scheme. Water flows through the culvert and discharges first into the monsoon channel via 'the windows' and ultimately into Portland Harbour (provided the Portland Harbour end of the system is not tide-locked – refer to **Section 3.1**). During the winter 2013/14 storms, the flow of water through the system was calculated at 'the windows' to be approximately 28m³/s at its peak during the storm of 5th February 2014 (CH2M HILL, 2014b). This peak flow on 5th February 2014 occurred when water levels measured at 'the windows' peaked at 4.97mOD at a time more or less coincident with the highest tide levels recorded in Portland Harbour at Q Pier and highest wave and longest wave periods recorded by the Chesil wave buoy (CH2M HILL, 2014a). Figure 8.2 in **Appendix E** illustrates the telemetry data associated with this 5th February 2014 event. The flow of water through 'canns' is a significant factor in flooding of the A354 Portland Beach Road in particular, as this is the primary flood pathway particularly in the undefended section of the BMP area as identified in modelling of the 5th and 14th February 2014 events reported in CH2M HILL (2014b) which was only able to replicate the flooding experienced during these events when percolation flow through the beach was included in the model. In addition, along the Monsoon Drain 'canns' pushed sediment into the open channel thus reducing the capacity of the channel to convey water to Portland Harbour (see **Figure 2.11**). The modelling reported in CH2M HILL (2014b) suggests that if the channel capacity were reduced by 50% as a result of such infilling, then flood depths along the adjacent A354 Portland Beach Road could be up to 0.15m higher than if the channel was at design capacity.

The high tide level is identified by Posford Duvivier (1998b) as an important factor for achieving significant percolation through the beach. Strong wave action and wave set up are also likely to be important as they add to saturation of the beach face. Extreme sea levels in conjunction with significant wave activity are therefore considered to be important factors for flooding to occur on the eastern side of Chesil Beach via this percolation mechanism. The Environment Agency monitors the water level using piezometers installed at a number of points within the beach (refer to **Sections 4.1.9 and 4.4.2**). **Records from this monitoring show that the time difference between peak high tide level and peak water level within the beach is approximately 2 hours** (Environment Agency, 2009a).

Research by Masselink *et al* (2009) has also highlighted the importance of understanding water levels both on the seaward and landward sides of barrier beaches and within the barrier beach itself. The information collected from boreholes at one part of the beach by the Environment Agency is unlikely to be sufficient to provide data to relate this research to Chesil Beach. This is also

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compounded by the lack of recording of tide levels on either side of the beach. Further details of this are provided in Section 3.1 of **Appendix E**.

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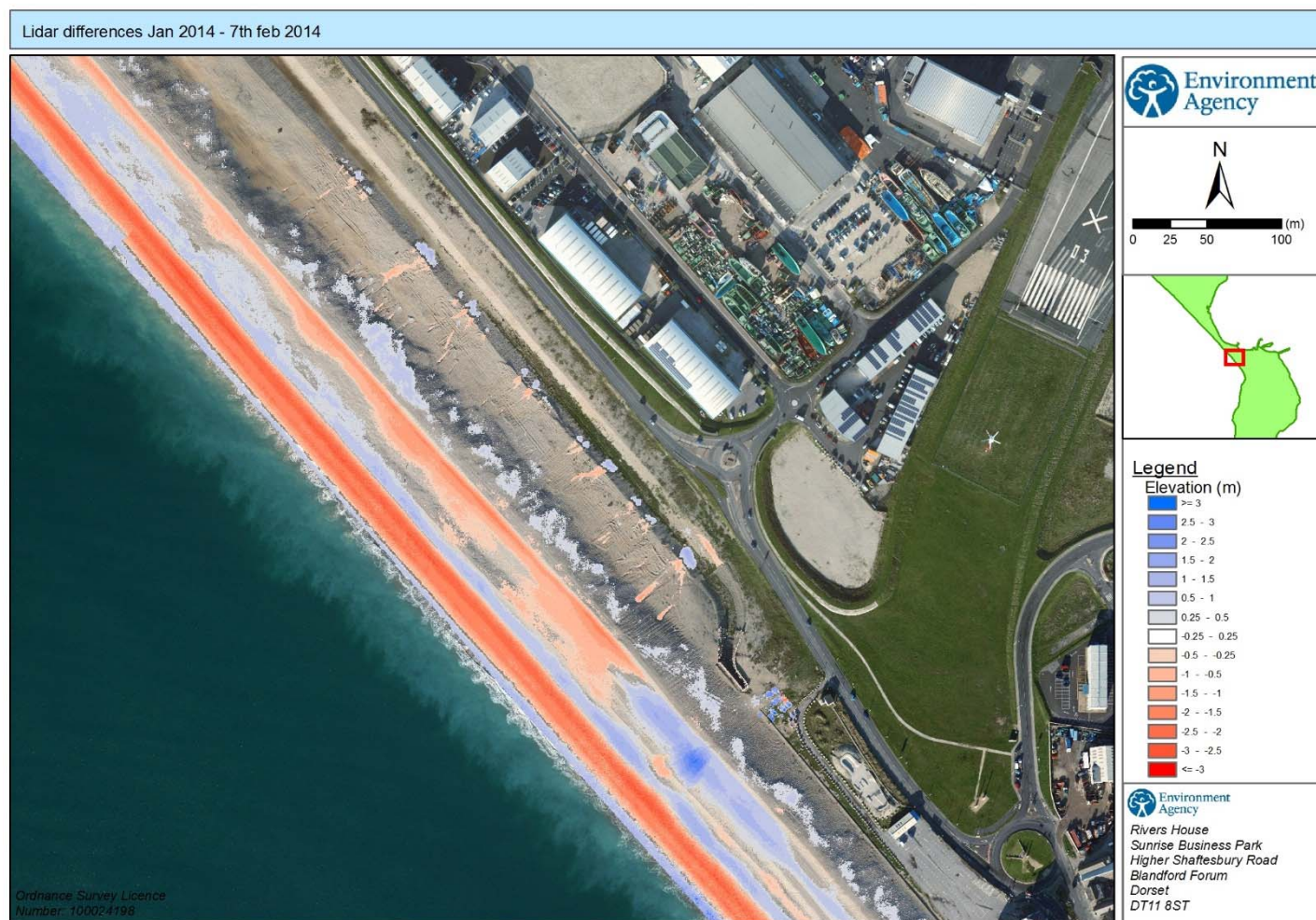


Figure 2.11 *LiDAR difference plot showing change in volume between January 2014 and 7th February 2014 LiDAR surveys, with accretion evident in the Monsoon Channel as a result of 'canns' pushing sediment into the channel.*

2.8 Environmental Characteristics

This section provides an overview of the environmental setting and identifies key environmental features within the vicinity of BMP area (refer to **Figure 1.1** above). The section is structured around a number of environmental topics as highlighted in the first column of **Table 2.7**. These follow the recommended structure contained in the Beach Management Manual (CIRIA, 2010). The second column in **Table 2.7** makes reference to the environmental aspects documented in Annex 4 of the European Union Directive 2011/92/EU ‘on the assessment of the effect of certain public and private project on the environment’ (the EIA Directive). This is provided by way of cross-reference to the EIA requirements such that the information in this BMP is able to be developed further should the need arise at a future date, e.g. if future works are needed that are determined to present a significant scale or impact as to need a statutory Environmental Statement (ES) to accompany the consent applications (refer also to **Section 1.6**).

Table 2.7 A summary of environmental topic and cross-reference to EIA Directive topics

Environmental topics (with reference to CIRIA, 2010)	Reference Annex 4 of the EIA Directive
Geology and Geomorphology	Soil
Sediment quality	Soil
Water quality	Water
Ecology	Flora and Fauna
Fisheries	Material Assets
Navigation	Material Assets
Landscape setting	Landscape
Archaeology and Cultural Heritage	Material Assets
Air quality	Air
Noise	Population
Amenity value	Population

2.8.1 Geology and Geomorphology

The following text on the geology and geomorphology of Chesil Beach has been summarised from Bray (2007) and the Bray *et al* (2004). Whilst much of this information is already included in **Sections 2.6 and 2.7**, it is also included here to provide a useful summary and context to the designation features of the area (refer also to **Section 1.3.1**).

Chesil Beach is a linear barrier beach and represents one of three major coarse clastic structures on the British coast. It extends some 28km from the piers in West Bay to the cliffs on the north western edge of the Isle of Portland. The beach is connected to the mainland at either end but is backed along 13km by the Fleet Lagoon. In the south, at the Isle of Portland, the cliffs are internationally recognised for their geology exposures, as too are the cliffs that line the eastern shore of the Fleet.

The evolution of Chesil Beach has been the subject of numerous studies with Bray *et al* (2004) referencing Carr and Blackley (1969) as the most comprehensive. As quoted below, Bray (2007) listed a chronological sequence based on a number of texts to describe this evolution citing Carr and Blackley (1973) Bray (1992a, 1992b, 1996, 1997a, 1997b, 1999), High-Point Rendel (1997; 2000) and Brunsden (1999) amongst others:

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1. *"The initial forerunner of Chesil probably existed as a bank well offshore of the present beach some 120,000 years before present (BP). This bank was contemporaneous with the second development of the Portland raised beach. It is uncertain whether this beach would have stretched across the full extent of Lyme Bay, because raised shorelines have been identified at Hope's Nose and near to Start Point, but substantial associated raised gravel deposits have yet to be identified.*
2. *During the last glacial period (Devensian) when sea level was up to 120 m lower than at present, a series of sand and gravel deposits accumulated on what is now the floor of Lyme Bay. These probably comprised material from the Portland raised beach, solifluction deposits, river gravels and fluvio-glacial deposits laid down on the floor of Lyme Bay by meltwaters at the end of the Devensian.*
3. *Formation of the present Chesil Beach began at the end of the Devensian (20,000- 14,000 years BP) when rapidly rising sea-level caused erosion of these deposits and wave action drove the sands and gravels onshore as a barrier beach.*
4. *Close to the land, the beach overrode existing sediments and the Fleet Lagoon was rapidly filled with silt, sand, peat and pebbles. Dating of peat samples retrieved from boreholes suggest that infilling began about 7,000 BP and was virtually complete by 5,000 BP. Such deposition requires shelter, so a significant barrier must have existed at this time indicating that Chesil Beach had formed at or slightly seaward of its present position by 4000-5000 BP when sea level approached its present elevation. Cores described by Coombe (1998) suggest that the initial Chesil Beach was predominantly sandy rather than gravel-rich, with layers of shells and coarser materials indicative possibly of intervals of overwashing.*
5. *Relict cliffs abandoned in East Devon and West Dorset by falling sea levels in the early Devensian were re-activated around 4,000-5,000 years BP by marine erosion and supplied large quantities of gravel to the shore. Material is believed to have been yielded initially from the reworking of extensive debris aprons located at the cliff toes with erosion cutting into in-situ lithologies only in more recent millennia (Brunsden, 1999). Detailed budget and sedimentological analysis indicates that some 30-60 million cubic metres of gravel could have been supplied from these sources (Bray 1996; 1997a; High-Point Rendel 1997).*
6. *Much of the cliff gravels supplied to the shore are believed to have drifted to the east via a series of pocket beaches (Charmouth, Seatown and Eype) regulated by alternate "open" and "closed" transport at headlands eventually to nourish and enlarge the prototype sandy Chesil Beach which would have acted as the sink for this material (Bray 1996; 1997a 1997b; Brunsden 1999).*
7. *Coastal recession and human interventions over the past 500 years appear to have depleted the beaches to the west of West Bay and resulted in increasing prominence of headlands. It has reinforced the pocket beaches as a series of distinct sub-cells leading to dislocation of the gravel transport pathway towards Chesil. The beach must now be regarded as a closed shingle system of finite volume and is likely to be sensitive to future environmental changes e.g. sea-level rise."*

Sediment transport on Chesil Beach is driven by waves. It is exposed to both locally generated wind waves and swell waves generated by mid-Atlantic low pressure systems. Modelling results undertaken as part of the *Futurecoast* Project (Halcrow, 2002) have suggested that small change in

wave direction can result in significant changes in longshore energy impacting on transport rates. Beach recession rates are low and highest opposite Portland Harbour. Carr and Blackley (1974), cited in Bray *et al* (2004), postulated that the mechanisms responsible for this recession were delayed response to sea level rise, increased storminess, change in wave direction and diminution of beach volume.

The beach represents the southerly extent of the Jurassic Coast and the World Heritage Site and due to its uniqueness is one of the most important coastal geomorphological sites in the UK. This importance is reflected in the area's SSSI designation, Chesil and the Fleet SSSI, which lists the beach as a classic landform. The bank and low cliffs along the landward edge of the Fleet are also listed as providing important exposures of Middle and Upper Jurassic rocks. None of the BMP Management Units are within Regionally Important Geological Sites (RIGS) although the area is covered by the Dorset Local Geodiversity Action Plan (refer to **Appendix B**). The RIGS sites are to the north at Abbotsbury and to the south on the Isle of Portland.

Isle of Portland SSSI refers to the Portlandian fossil reptiles that occur in the West Cliffs in the description and reasons for notification. These cliffs represent the southern limits of Chesil Beach.

2.8.2 Sediment quality

There are various reports about the physical quality of beach sediment along the BMP frontage. Visible beach material was categorised by Carr and Blackley (1969), cited in Bray *et al* (2004), as approximately 98.5% chert and flint. This demonstrated that pebble size above the low water mark increased from west ($D_{50} \sim 0.5\text{cm}$) to east ($D_{50} \sim 5\text{cm}$) with a corresponding increase in beach face gradients. This was confirmed by a pebble sample programme by Babbie Group in 1992 (Babbie Dobbie, 1992). Further information about the sediments along the BMP area is provided in **Section 2.5.1**.

No chemical analysis of beach sediments samples has been reported in available literature (refer to **Appendix H**).

2.8.3 Water quality

No water quality monitoring occurs along the BMP frontage of Lyme Bay under the Bathing Water Directive as the site is not designated as a bathing water beach.

Water quality monitoring is undertaken to monitor compliance with WFD good ecological status in accordance with the requirements set out in the South West River Basin Management Plan (refer to **Section 1.7.9**).

The Fleet and Portland Harbour are designated shellfish waters under the Shellfish Waters Directive (2006/11/3EEC). In addition, The Fleet is also a Classified Bivalve Mollusc Harvesting Area. The Fleet is also identified as a Bass Nursery Area and a Nitrate Vulnerable Zone, where pollution from run-off from land surrounding The Fleet has the potential to cause eutrophication. Water Quality is monitored in regards to these aspects by the Environment Agency and the Centre for Environment, Fisheries and Aquaculture Science (Cefas).

The extents of these various water quality related designations are shown on **Figure 2.12**.

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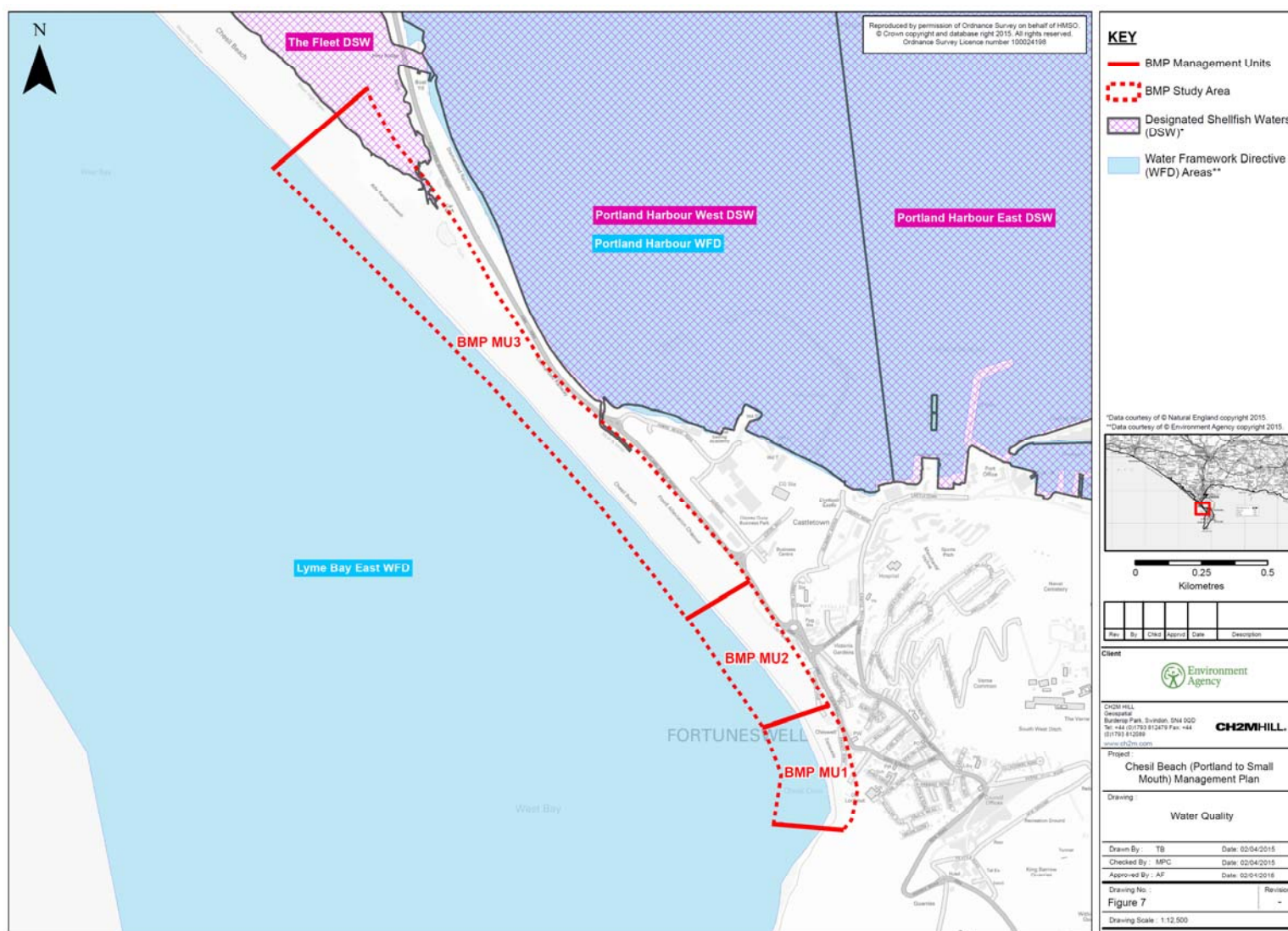


Figure 2.12 Water quality designations in the BMP area.

2.8.4 Ecology

Chesil Beach supports a number of rare habitats:

- Coastal Lagoons;
- Annual vegetated drift lines;
- Perennial vegetation of stony banks;
- Mediterranean and thermo-Atlantic halophilous scrub (*Sarcocornetea fruticosi*); and
- Vegetated sea cliffs.

These habitats are the features of European importance and the primary reason for the designation of the Chesil and the Fleet SAC. The vegetated sea cliffs are listed in the Isle of Portland to Studland Cliff SAC designation. These features are also cited in the Ramsar information sheet on the Chesil Beach and the Fleet Ramsar site.

The species listed in the SAC and Ramsar citations as being supported by these habitats are two species of eelgrass *Zostera* and three species of tasselweed *Ruppia* including the rare spiral tasselweed *R. cirrhosa* present in the Fleet. Sea beet *Beta vulgaris ssp. Maritima* and orche *Atriplex ssp* are species of note present in the annual vegetation of the drift lines. Sea-kale *Crambe maritima* and sea pea *Lathyrus japonicus* are common in the stony banks to the east of the site. Sea-blite *Suaeda vera*, and sea-purslane *Atriplex portulacoides* are listed as lining the Mediterranean and thermo-Atlantic halophilous scrub.

The spatial extent of the designated habitats, described above, was detailed in the National Vegetation Classification Survey of Annex 1 Listed Habitats at Chesil and the Fleet SAC (Groome and Crowther, 2005). This survey reported 95.4ha, or approximately a third of the survey area, as being occupied by Perennial Vegetation of Stony Banks. Smaller areas of Annual Vegetation of Drift Lines (1.4ha) and Mediterranean and Thermo-Atlantic Halophilous Scrub (9.2ha) were reported as being restricted to a narrow fringe along the margins of the Fleet. The survey report stated that the maximum potential areas for these drift line and scrub habitats on the southern margins of the Fleet as being 10ha to 15ha.

On the stable landward side of the beach, there are large and nationally important populations of Sea Kale *Crambe maritima*, Yellow-horned Poppy *Glaucium flavum*, Sea Pea *Lathyrus japonicus* and Shrubby Sea-blite *Suaeda fruticosa*. Sea Holly *Eryngium maritimum*, Portland Spurge *Euphorbia portlandica* and Little-robin *Geranium purpureum*, a Red Data Book species, are also present. Furthermore, the beach is the breeding site for about 50 pairs of Little Tern *Sterna albifrons* and 30 pairs of Ringed Plover *Charadrius hiaticula*, the only sizeable populations of these species in south west Britain. These species are listed in the Chesil Beach and Fleet SSSI citation.

The Little Tern is listed in the SPA citation as a qualifying species and noted in the Ramsar information sheet as being noteworthy. The Dark-bellied Goose *Branta bernicla bernicla* is listed as a qualifying species in both designations.

The Fleet contains a number of unusual mollusc associations, notably invertebrates and rare anemones. The anemone *Nematostella vectensis* is known from only a few British locations and nowhere else in Europe. In addition, the Fleet is one of the few nurseries of Bass *Dicentrarchus labrax* in Britain. This is recognised as the Fleet is designated as a bass nursery area.

The hinterlands are important for many species of birds and insects for shelter, breeding and food.

The ongoing management of both the SAC and SPA features of Chesil Beach and The Fleet are subject to a Site Improvement Plan produced by Natural England in 2014 (refer to **Section 1.7.7**).

The *Dorset Biodiversity Strategy* (Dorset Biodiversity Partnership, 2003) and *Action for Biodiversity in the South West* (South West Regional Biodiversity Partnership, 2004) are the relevant biodiversity plans for Chesil Beach. There is currently no local Biodiversity Action Plan (BAP). The following are listed as UK priority BAP habitats and are potentially represented on Chesil Beach. The habitat objectives are quoted under them:

Maritime cliff and slope

- (i) Maintain the extent and quality of the existing resource;
- (ii) Increase the extent of eroding cliffs over time, by allowing natural processes of cliff mobility to continue;
- (iii) Restore natural vegetation where possible, i.e. through removal of non-native species;
- (iv) Increase and link areas of cliff top semi-natural habitats;
- (v) Continue to survey and monitor to improve our knowledge of the habitat; and
- (vi) Raise awareness of the wildlife value of the habitat.

Coastal Vegetated Shingle

- (i) Maintain the extent and quality of the existing resource;
- (ii) Encourage reinstatement of wetland vegetation on shingle sites (where appropriate), by scrub clearance and grazing;
- (iii) Prevent, where possible, further exploitation of, or damage to, existing sites through human activities, through visitor management;
- (iv) Improve the condition of vegetated shingle structures that are degraded/damaged;
- (v) Continue to survey and monitor to improve our knowledge of the habitat; and
- (vi) Raise awareness of the wildlife value of the habitat.

Sabellaria alveolata reefs

- (i) Maintain the extent and quality of the existing resource;
- (ii) Survey to determine the full extent of the habitat;
- (iii) Ensure water quality is sufficient to maintain habitat;
- (iv) Re-establish/ restore sabellaria alveolata reefs where they were formerly present;
- (v) Continue to survey and monitor to improve our knowledge of the habitat; and
- (vi) Raise awareness of the wildlife value of the habitat.

Sheltered muddy gravels

- (i) Maintain the extent and quality of the existing resource;

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- (ii) Continue to survey and monitor to improve our knowledge of the habitat; and
- (iii) Raise awareness of the wildlife value of the habitat.

The remaining priority BAP habitats have the following group objectives listed for them:

- (i) Maintain the extent and quality of marine priority habitats;
- (ii) Assess feasibility of restoration of damaged habitats;
- (iii) Improve understanding by promoting research and survey; and
- (iv) Promote awareness amongst public, especially divers.

These habitats are *Saline lagoons*, *Seagrass beds*, *Sublittoral sands and gravels*, *Maerl beds* and *Mytilus edulis beds*.

In addition to the above, the BMP area has also recently been further designated for its broad-scale marine habitats including high energy inter-tidal rocks and inter-tidal coarse sediment, as well as for marine fauna of Pink Sea-fan *Eunicella verrucosa* and Native Oyster *Ostrea edulis* under the Chesil Beach and Stennis Ledges MCZ. Further MCZ designation may occur in the future if the South of Portland recommended MCZ is also formally designated for its broad-scale marine habitats including high energy littoral rocks; subtidal sand, coarse and mixed sediment; and the Portland Deep feature of geological/geomorphological importance.

The extent of all these various designations in relation to the BMP area are shown in **Figures 2.13a and 2.13b**, whilst the extent of BAP habitats is shown in **Figure 2.14**.

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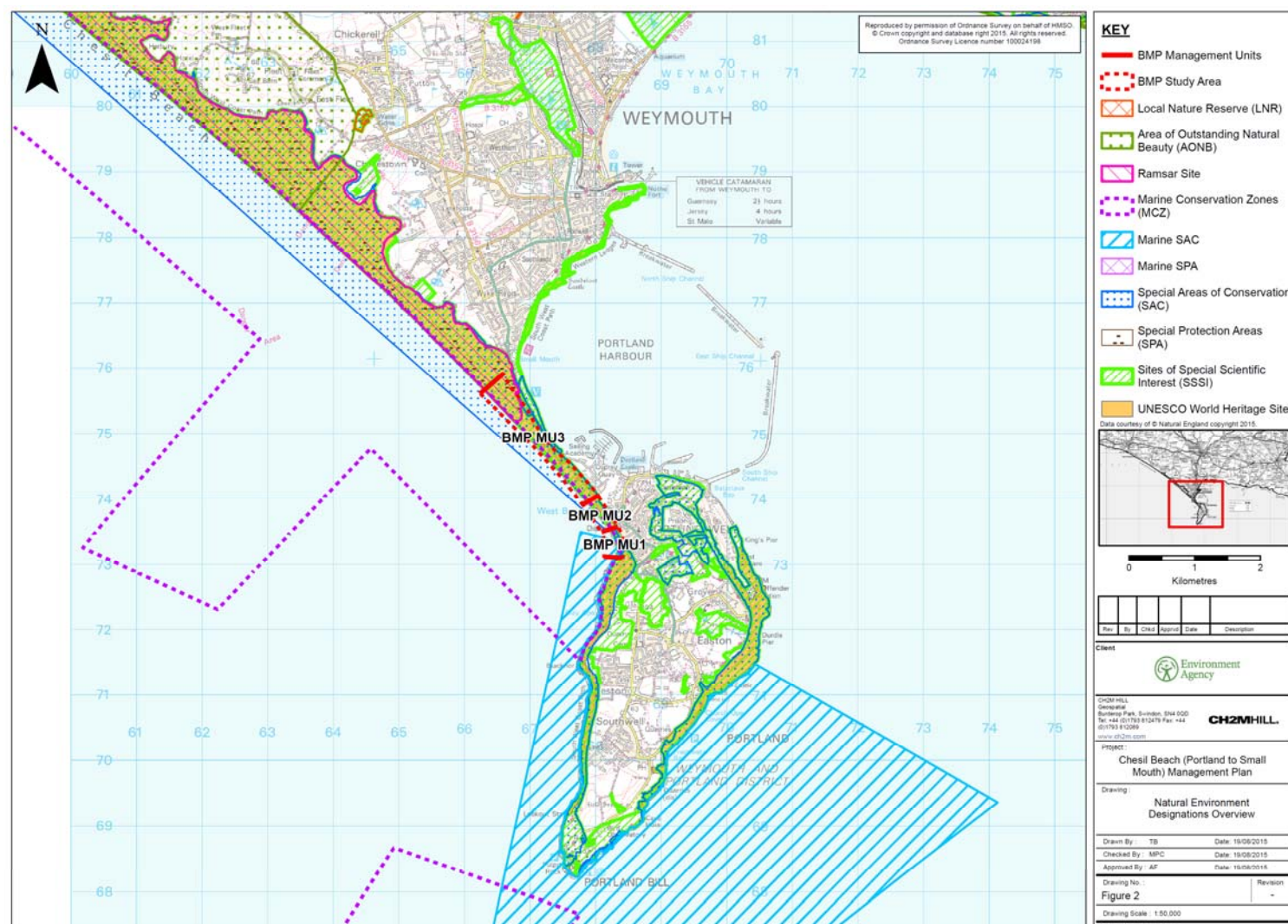


Figure 2.13a Natural conservation designations in the BMP area (overview).

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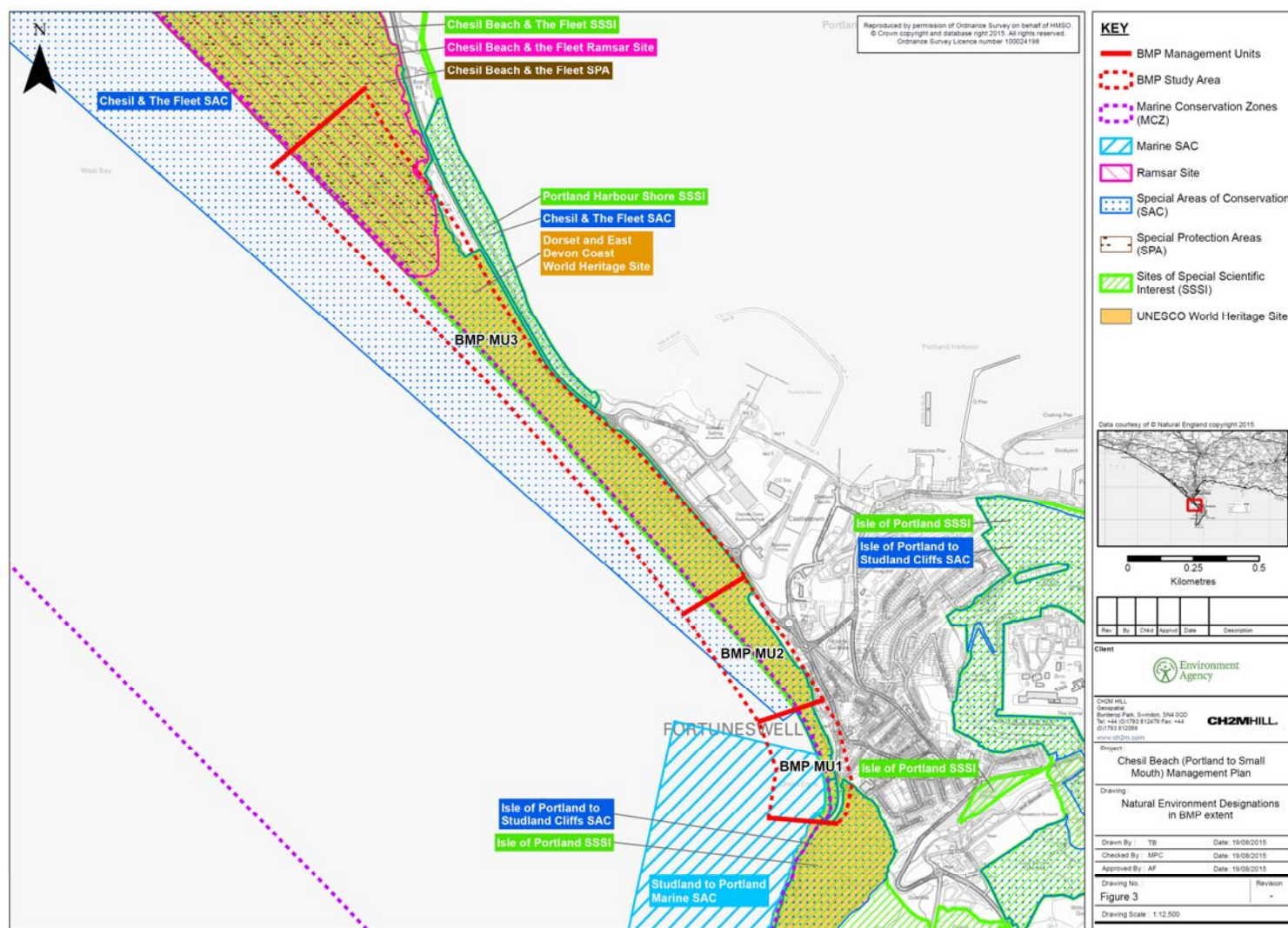


Figure 2.13b Natural conservation designations in the BMP area (zoomed).

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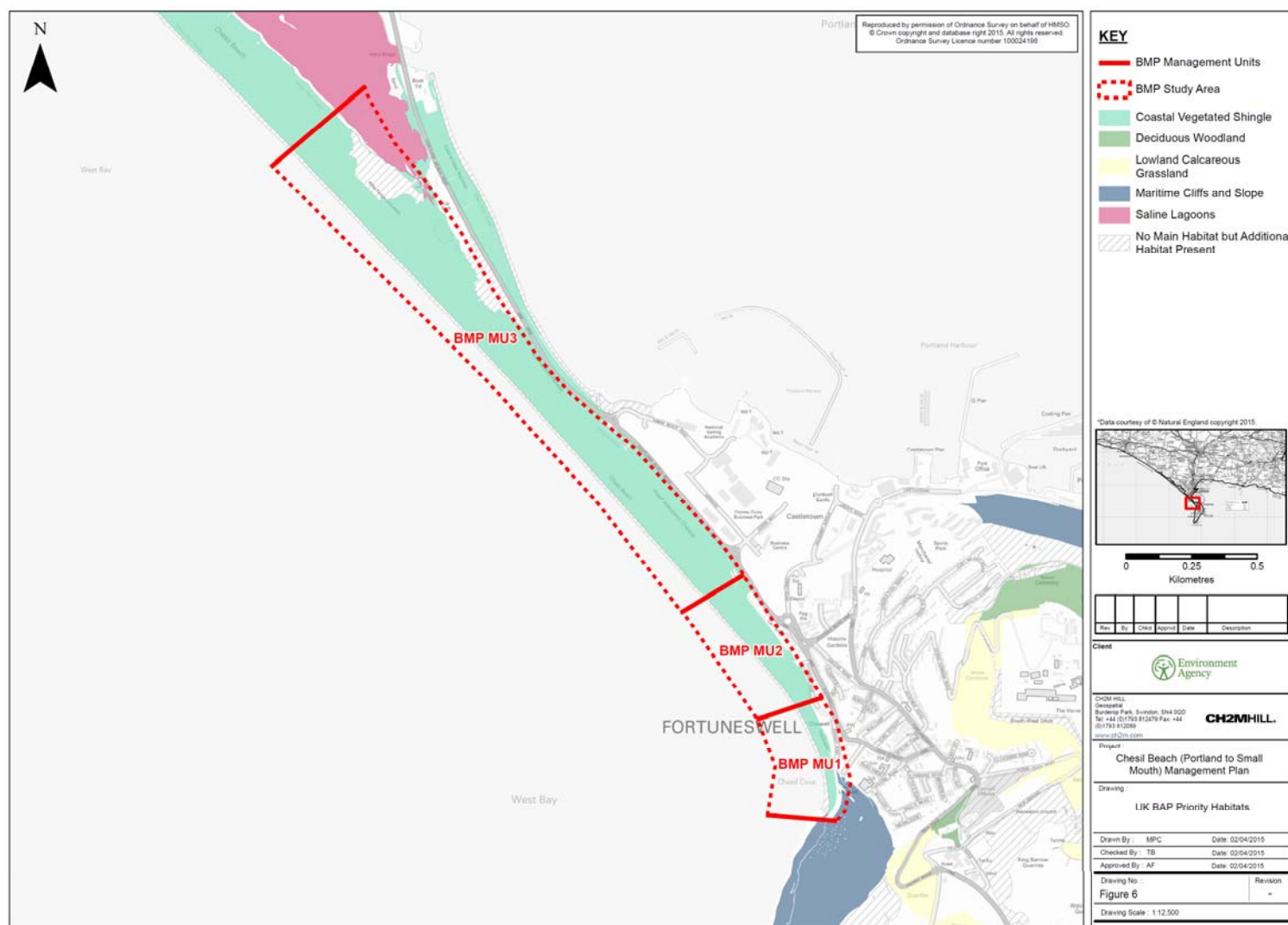


Figure 2.14 UK BAP habitats in the vicinity of the BMP area.

2.8.5 Fisheries

The BMP area is within the Southern Inshore Fisheries and Conservation Authority's (IFCA) district.

The village of Chiswell has a long history of commercial fishing from boats launched off Chesil Beach. This has now largely ceased, although the nearshore area is still used by local fisherman from boats hailing from local harbours such as Weymouth and West Bay. The main commercial fishery activity in the area is now oyster and mussel farming in The Fleet and Portland Harbour (refer to **Section 2.8.3**).

The main fishery activity along the beach is recreational sea angling. This is popular with beach angling along the length of the BMP area year round.

2.8.6 Navigation

There are no significant navigation issues in the vicinity of the BMP area as it is beyond the routes of commercial and other vessels transiting the English Channel. The nearshore area is, however, used by local fishing boats (refer to **Section 2.8.5**) as well as commercial dive charter boats and private boats.

2.8.7 Landscape setting

The BMP Area is within the following landscape designated areas:

- Purbeck and West Dorset Heritage Coast; and
- Isle of Portland NCA 137.

In addition, the following landscape designations are within 2km of the site:

- Dorset AONB.
- Weymouth Lowlands NCA 138.

A number of the above landscape designations are represented on **Figure 2.13a** above and **Figure 2.15** below. **Appendix B** contains further details regarding designation citations and further information.

2.8.8 Archaeology & Cultural Heritage

There are a number of Scheduled Monuments in the vicinity of the BMP area, including:

- The Verne Citadel;
- RAF Portland;
- Portland Castle;
- Portland Open Fields;
- Battery (Fortuneswell); and
- Sandsfoot Castle.

In addition, there are a number of Grade 2 listed buildings in the surrounding Chiswell and Fortuneswell areas, including the Cove House Inn situated immediately behind the seawall in MU1, as well as a number of non-designated archaeological sites (refer to **Figure 2.15**).

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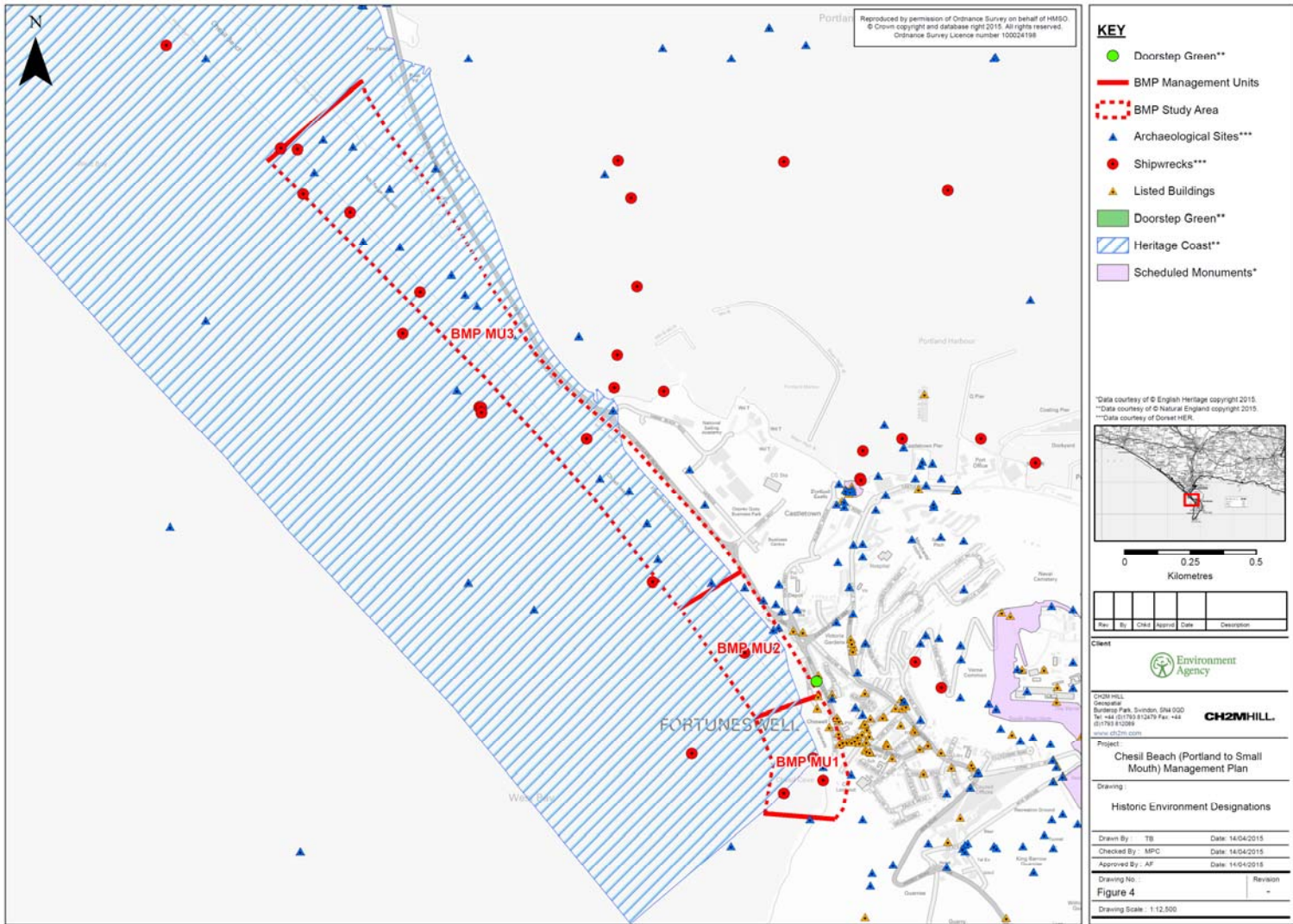


Figure 2.15 Historic environment features.

2 SUPPORTING INFORMATION

Of particular interest are the non-designated archaeological sites which may represent the remains of Second World War defences buried on the beach. In addition, there is a concrete feature located at the back of the Chesil Beach near the Chesil Beach Visitor Centre that is understood to be the remains of a pre 1st World War firing range (see **Figure 2.16**), with the feature itself being a concrete footpath that linked firing positions. It is not thought that the path itself has any substantial foundations (Personal Communication, 6th February 2010). From the information reviewed, as shown plotted in **Figure 2.15**, it is not believed that this feature is even noted as a non-designated archaeological asset.

Shipwreck locations are scattered along the shoreline of Chesil Beach as represented in **Figure 2.15** above and have been recorded throughout Britain's maritime history. The wrecks are particular concentrated in an area known as the ship's graveyard, Deadman's Bay. **Figure 2.17** provides an illustration of the Royal Adelaide floundering close to Chesil Beach in 1872. This ship was recorded as iron built of 1385 tons. This picture, although subject to artist interpretation, shows the exposure of Chesil Beach to storm swell waves that have shaped the beach.



Figure 2.16 'Concrete' feature at the back of Chesil Beach in the vicinity of the Visitor Centre.

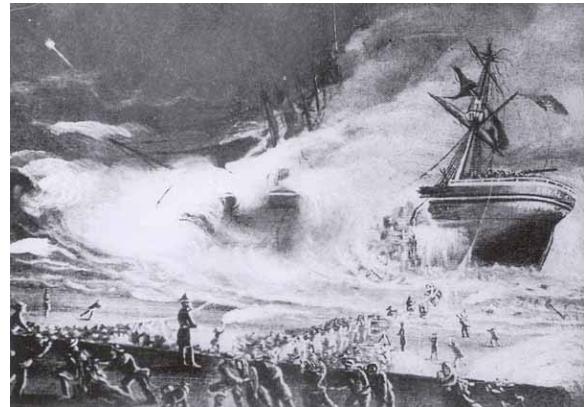


Figure 2.17 The Royal Adelaide in trouble yards from Chesil Beach 1872 (from Burton Bradstock online, 2015).

The archaeological potential (a qualitative assessment supported by the assessor's notes) of Chesil Beach and the surrounding area was described by the draft *Dorset Rapid Coastal Zone Assessment Survey* (Wessex Archaeology, 2004) as medium and high for the Fleet and West Portland areas respectively. The entire length of Chesil Beach was recorded as having eight Late Mesolithic sites, two Neolithic sites, five Bronze Age sites, seven Roman sites and one Saxon site. This provides an indication of the archaeological potential of the area although it is unclear how many of these sites are designated.

2.8.9 Air quality

There are no Air Quality Management Areas in the study area.

2.8.10 Noise

No baseline data on existing background noise level has been sourced for this BMP. This may be required prior to any management activities depending on their scale and scope to produce elevated levels of noise.

3 SCHEME DESIGN

3.1 Scheme Description

The current sea defences along the BMP frontage were constructed in a number of phases between 1958 and the 1980s (refer to **Section 1.3.3** above and **Figures 3.1 to 3.6** below). The south-easternmost part of MU1 still retains the seawall and slope stabilisation measures constructed between 1958 and 1965, however the majority of the defences seen in the present day are the result of construction in the 1980s following two significant flood events in the late 1970's. The scheme that was designed by C.H. Dobbie and Partners (1980) aimed to reduce the potential for flooding at Chiswell village and the main road between Portland and Wyke Regis (the A354 Portland Beach Road).

Details of the 1958 to 1965 scheme construction are limited, although some information has been identified and is included in **Appendix I.4**. This information, along with information from discussions with former local authority engineer and now local historian, Stuart Morris, has been used to develop a typical cross-section of the coastal defence system along this part of the frontage (see **Figure 3.3**).

The 1980s-built scheme consists of a sheet piled cut-off barrier through the beach to reduce the flow of salt water through the shingle material, coupled with a large perforated concrete box culvert, constructed underground, to provide a land drain along the sea side of the sheet piles. This land drain was designed to reduce the build-up of seawater in the beach which would otherwise weaken its structure and provide the potential for flooding in Chiswell (refer also to **Section 2.7**). To improve its structure, the beach itself was reinforced for the entire length of the culvert using layers of gabion-type wire baskets, which were interlocked and filled with stone.

The piling and culvert run parallel to the beach north-westward from the Cove House Inn and terminate in a reinforced concrete outlet structure known as 'The Windows' from which the flow from the culvert is discharged into an open ditch. This receiving ditch, known as 'the monsoon ditch', eventually drains into the Portland Harbour via a box culvert bridge under the main road which links Portland with Wyke Regis. The buried reinforced concrete box culvert and steel sheet pile cut-off barrier constructed parallel to the beach on approximately a north-west line from the Cove House Inn, at the end of Chiswell promenade.

The area around Victoria Square was left open for drainage into Portland Harbour following overtopping. There is also a small drain from Victoria Square which takes an unknown route out to the harbour. This was mapped by the Environment Agency via a CCTV survey in Autumn, 2010, and details are held by the Assets Performance Team in the Environment Agency's Blandford office. The drain opening is regularly inspected and kept clear of debris etc.

The defence improvement scheme was built in four stages:

- Stage 1 to modify and raise the seawall in 1981-3 (see also **Figure 3.4**);
- Stage 2 to install an interceptor drainage in 1985-7 (see also **Figure 3.5**);
- Stage 3 to raise the A354 Portland Beach Road from 1.5m AOD to 3m AOD in 1987-8; and
- Stage 4 in 1991 to install gabion crest protection along part of the beach to the immediate north-west of the seawall, raising the crest by 1.5m to 14.85m (over a length of 1600m was

recommended) – see also **Figure 3.6**. The fill material used in the mattresses and gabions is screened beach shingle. The material is reported to have a minimum diameter (D) of 34mm (Halcrow, 2006). NB: a 150m trial length was installed in 1991 (with a 15yr design life). This was replaced and lengthened to 550m in 1998.

Such is the potential for storm damage and flooding at this location, that despite the construction of the flood defence scheme in the 1980s, the area still remains at risk. The 1980's scheme therefore also included a beach monitoring system, consisting of underground water level measurement from which valuable data can be obtained for the purpose of flood incident management and for use in any future flood risk management decisions (refer also to **Sections 2.7 and 4.4.2**).

Specific details of the 1980's scheme elements described above are provided on the scheme drawings. A register of the drawings available, as held by the Environment Agency in their Blandford office, along with scanned copies of these drawings, is provided in **Appendix I.2** of this BMP.

With regards to the introduction of gabions, the reason why the use of these was chosen was because they:

- (i) Would provide resistance to crest lowering should they be overwashed;
- (ii) Would provide resistance to crest cut back and would drop if the toe were exposed, minimising the risk of undermining; and
- (iii) Would mimic the natural beach and its response as far as possible.

They also slope into the body of the beach and are orientated towards the landward side, so that there would be no crest discontinuity if the beach crest shifted landwards. The tie wires on the gabions had an expected life of 10 years when installed in 1998, and a separate study to investigate the future of the gabions was carried out by the Environment Agency in 2012 (Halcrow, 2012).

Since the 1980's scheme was constructed, repairs to parts of the coastal defences have been carried out in:

- 1990, following storm damage;
- 2001, when gabion tie wires were fixed where previous ones had burst and additional sheets of mesh reinforcement were added over mattresses so that they would function as a more composite structure;
- 2010/11, when the south-easternmost part of the WPBC seawall in MU1 was repaired to replace the access steps and provide better protection to the toe of the seawall; and
- 2014, following storm damage caused over winter 2013/14 (refer to **Section 1.3.3**), a new toe protection structure was built along part of the seawall in MU1 (refer to construction drawings in **Appendix I.3**) and the gabion castle and much of the gabion mattress were completely re-built (refer to construction drawings in **Appendix I.4**).

3 SCHEME DESIGN

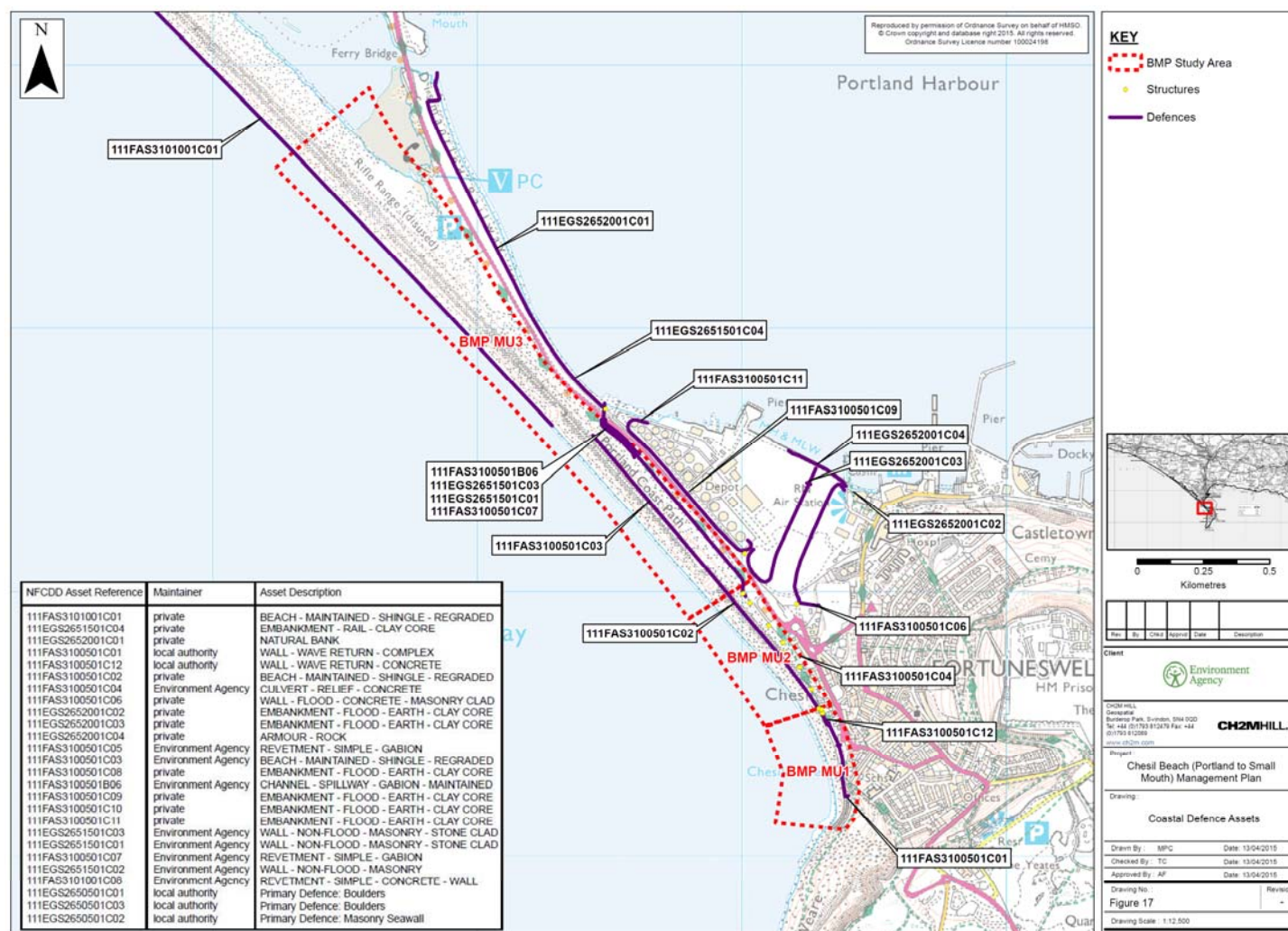


Figure 3.1 Coastal defence assets along the BMP frontage as defined in the Environment Agency's Asset Information Management System (AIMS).

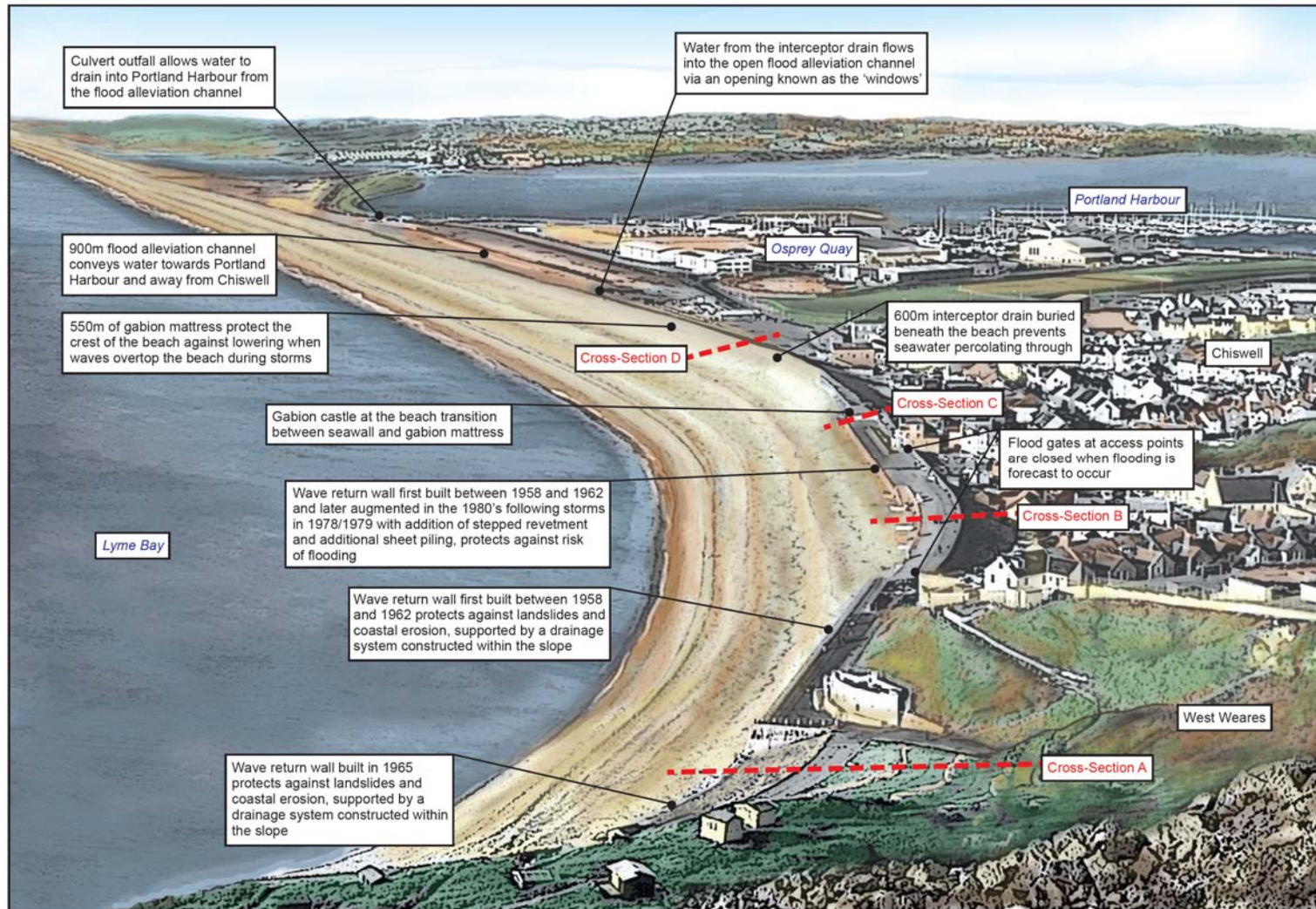


Figure 3.2 Overview of the coastal defence system along the BMP frontage. NB: copy also provided in Appendix P.

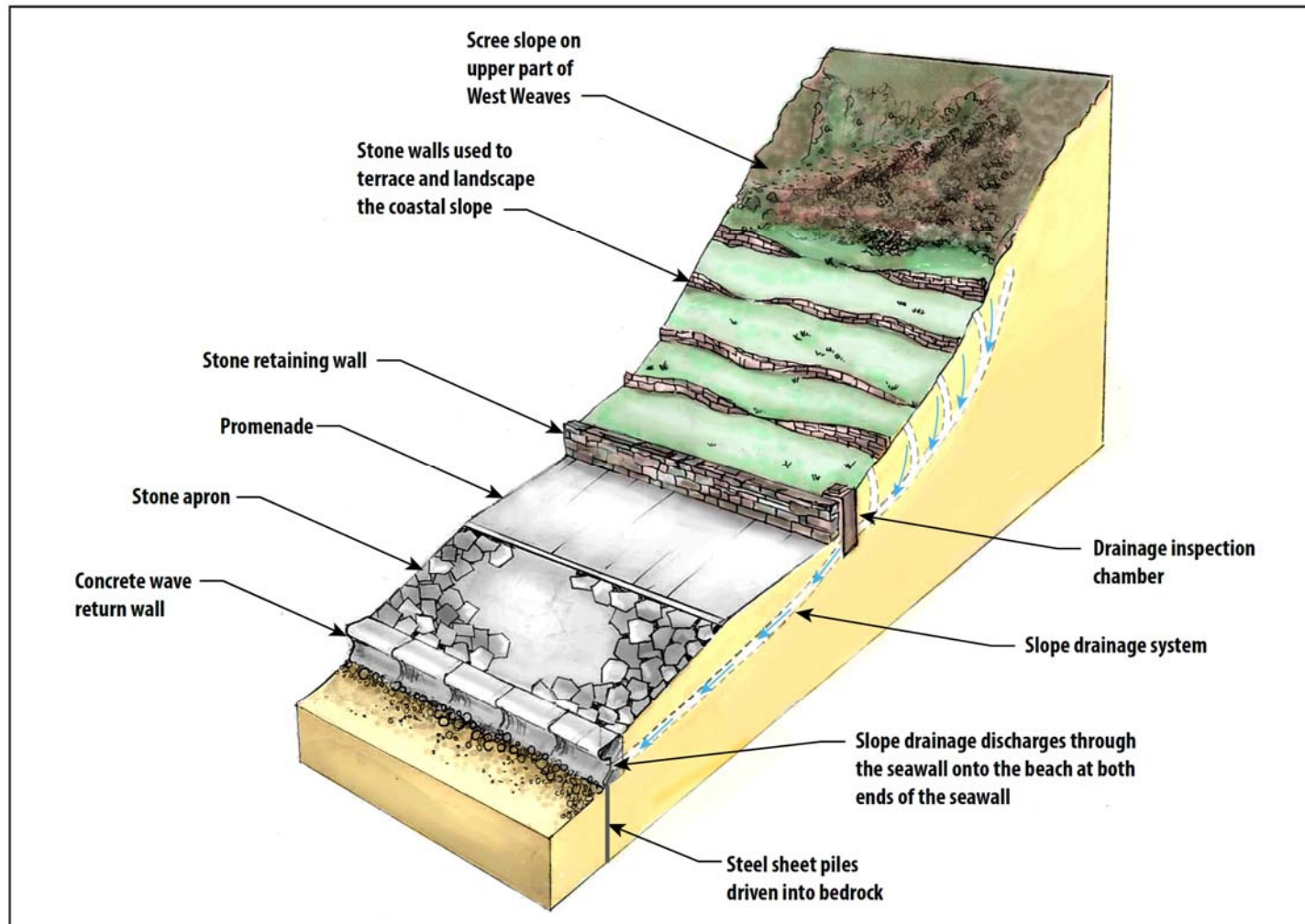


Figure 3.3 Typical section through the seawall and slope stabilisation measures at West Weares in MU1 (along cross-section A with reference to Figure 3.2 above). NB: copy also provided in Appendix P.

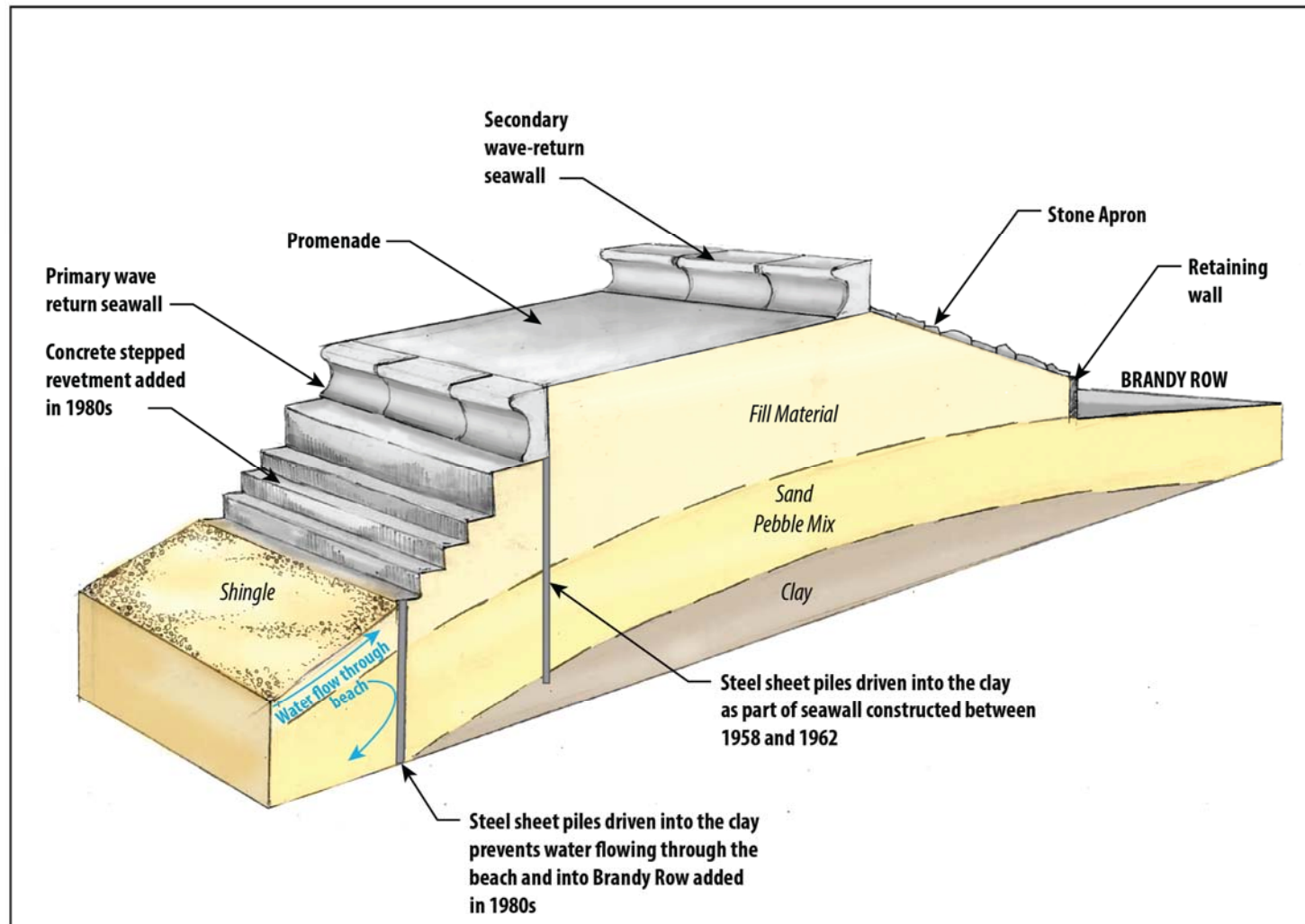


Figure 3.4 Typical section through the seawall in MU1 (along cross-section B with reference to Figure 3.2 above). NB: copy also provided in Appendix P.

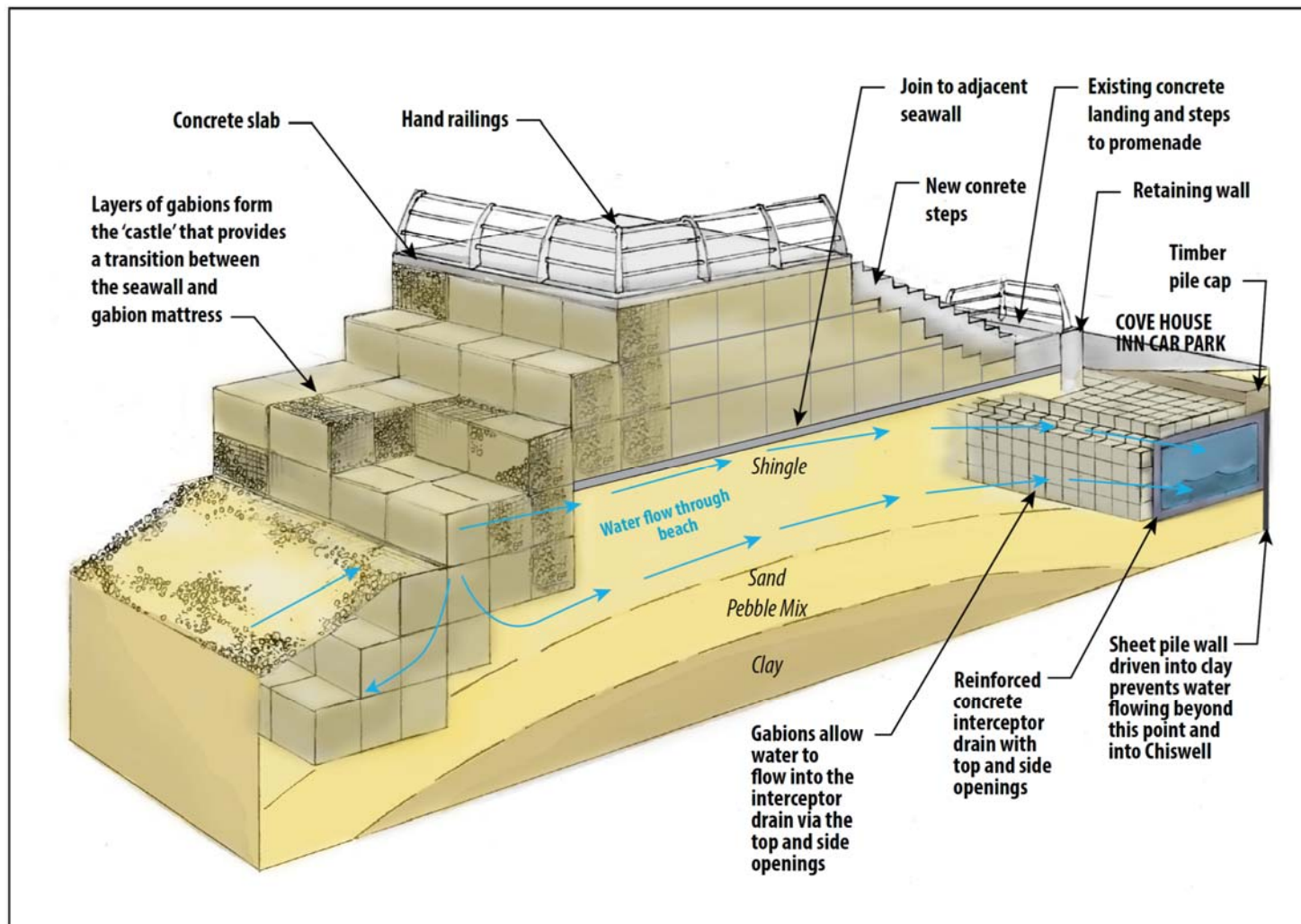


Figure 3.5 Typical section through the gabion castle at the boundary of MU1 and MU2 (along cross-section C with reference to Figure 3.2 above). NB: copy also provided in Appendix P.

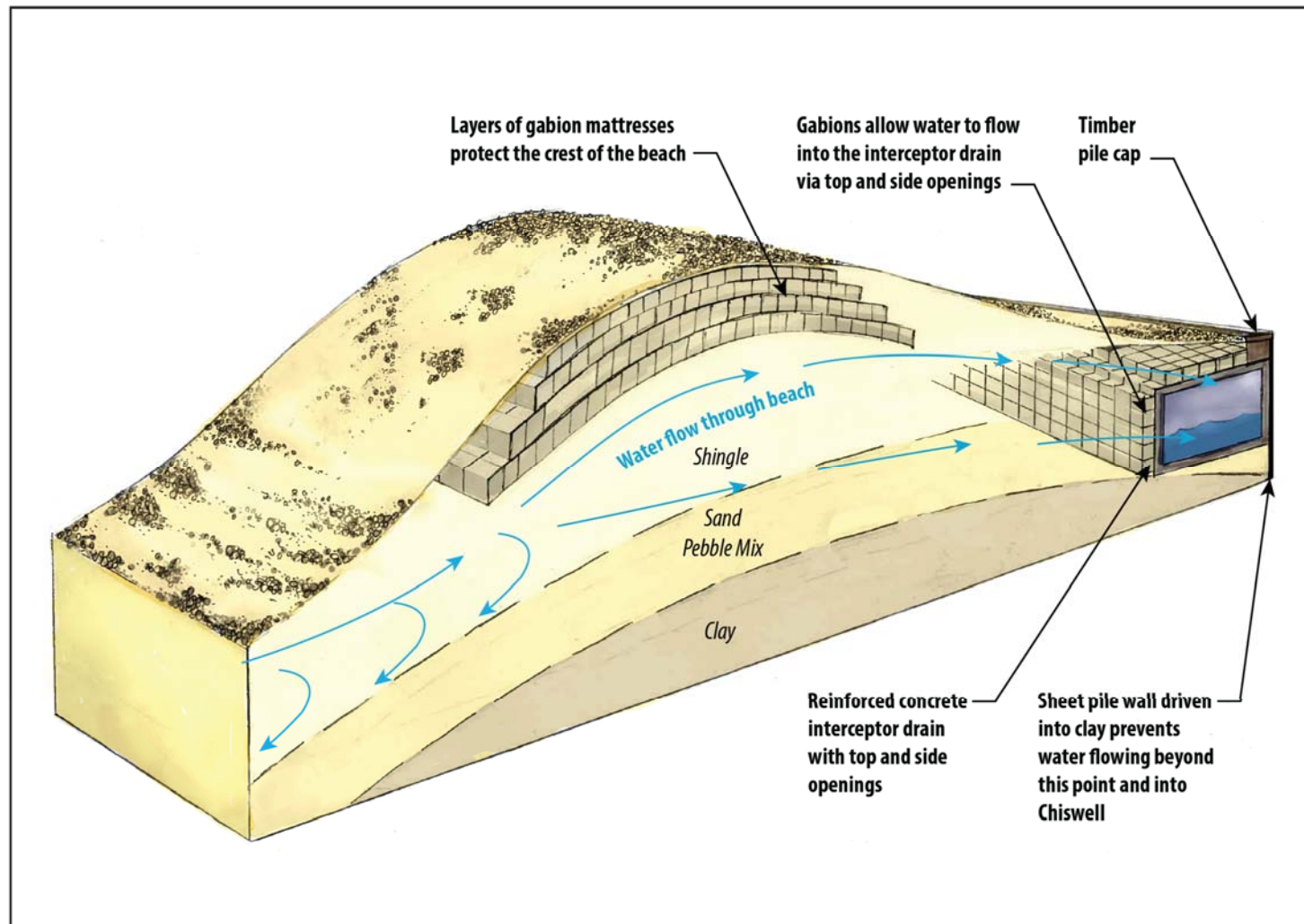


Figure 3.6 Typical section through the gabion mattress crest protection in MU2 (along cross-section D with reference to Figure 3.2 above).
NB: copy also provided in Appendix P.

3.2 Standard of Protection

The Chiswell sea defence scheme constructed in the 1980's (refer to **Section 3.1**), protects about approximately 160 residential and commercial properties at Chiswell with a capital value of around £16 million to a current SoP thought to be in the range of 6.7% to 10% Annual Probability of Occurrence (APO) (1 in 10 year to 1 in 15 year return period) against both overtopping and breaching (Environment Agency, 2009a). According to the *Strategic Flood Risk Assessment* (Royal Haskoning, 2006)), the SoP is expected to fall to 1:1 by 2056, although as discussed in **Section 1.4.1.1**, there is significant uncertainty about exactly how SoP is defined and analysed along the BMP frontage. *This uncertainty should be borne in mind when reading the remainder of this section.*

Overtopping and overwashing risk analysis carried out in developing the first version of this BMP 2010, sought to confirm what the current Standard of Protection (SoP) is along the BMP frontage, both for the present day and in 50 and 100 years' time allowing for the effects of climate change (allowing 10% increase in wave height) and sea level rise, both of which were based on the Defra guidance at the time (Defra, 2006). A summary of this analysis is presented in the following sections, whilst further detail provided in **Appendix J**.

3.2.1 Overtopping Analysis

Overtopping analysis was carried using a number of empirical methods to calculate overtopping discharge rates for two different defence types along the BMP frontage. The two frontage types and the empirical methodologies used to calculate overtopping for each are set out in **Table 3.1**.

Table 3.1 *Frontage types and methodologies used to derive overtopping discharge rates (refer also to Appendix J).*

Frontage type analysed	Empirical method(s) used for analysis
Shingle beach only and shingle beach with gabions	Van der Meer equations for overtopping of bermed structures (Van der Meer, 1998).
Shingle beach plus sea wall	EurOtop Wave Overtopping of Sea Defences and Related Structures: Assessment Manual (Environment Agency, 2007); and W178 Wave Overtopping of Seawalls, Design and Assessment Manual (HR Wallingford, 1999).

Input data for the overtopping analysis was the joint probability extreme wave and water level conditions described in **Section 2.3**. These values were used as they were, and remain, the most recent comprehensive data available covering a sufficiently wide range of return period conditions. In addition to the joint probability conditions, overtopping sensitivity to swell wave events was tested using swell wave data determined by HR Wallingford (1997) assuming a still water level of MHWS with these wave conditions.

All wave and water level condition data available related to an offshore point on about the -10mCD bathymetry contour. These conditions were transformed to the nearshore using the method of Goda as part of the overtopping analysis. To give the worst case overtopping discharge, waves were also assumed to be perpendicular to the shoreline.

In order to determine the SoP of the two types of frontage analysed, it was necessary to adopt tolerable overtopping discharge rate limits. For the shingle beach frontage, the structural limit advised by the *EurOtop manual* (Environment Agency, 2007) for this type of frontage is 0.1 l/s/m. Where the beach is backed by the seawall, the structural safety limit advised is 50 l/s/m, although the public safety limit is 0.1 l/s/m. These structural safety tolerable limits were used to determine the SoP along the BMP frontage, and form the basis of the discussion of SoP in the rest of this section. It should, however, be noted that these methods make some very significant assumptions in their application and assessment of SoP. For example, it is not possible within these methods to take account of crest lowering during the course of a storm event and its subsequent increased frequency of overtopping that in turn results in further crest lowering.

The analysis of overtopping discharge rates using extreme locally generated waves suggests that the current SoP of the undefended beach, in terms of structural safety, is between the 1 in 10 (10% APO) and 1 in 20 (5% APO) year return period, whilst the beach backed by the sea wall offers a SoP in excess of 1 in 200 years (0.5% APO). With the effects of climate change and sea level rise, the shingle beach SoP using locally generated wave conditions will reduce to below 1 in 10 years (10% APO) by year 50. No such reduction is indicated in the results for the beach backed by the sea wall for structural safety, although public safety is predicted to reduce to less than 1 in 100 (1% APO) by year 50 and less than 1 in 20 (5% APO) by year 100.

When consideration is taken of swell waves, then the overtopping discharge rates derived suggests that the SoP of the undefended beach (in 2010) is already below the 1 in 1 year return period (100% APO) and this will persist when sea level rise is taken into account. The SoP for the beach backed by the seawall is currently greater than the 1 in 100 year return period. The SoP here is not predicted to reduce if a 10m crest width is retained over time. If the crest width were to reduce to 5m, then for the 18s swell period cases, the SoP is predicted to reduce to less than 1 in 50 (2% APO) by year 50 and less than 1 in 1 (100% APO) by year 100.

When considering the SoP of the shingle beach in particular, it is important to remember that the SoP is likely to change during the course of a storm/swell wave event. For example, as overwashing occurs it causes crest lowering which in turn reduces the SoP.

In order to provide some verification of the overtopping analysis undertaken in developing the BMP in 2010, the results of the 2010 analysis were compared with previous work undertaken by others, notably the analysis carried out in developing the *Chiswell Strategic Flood Risk Assessment* (Royal Haskoning, 2006). The previous work by others used a single wave and water level condition stated as being a 1 in 200 (0.5% APO) year event with a range of different methodologies for calculating overtopping. To compare the analysis for this BMP in 2010 with the previous work, the input conditions stated in the SFRA (Royal Haskoning, 2006) were input to the methodologies described in **Table 3.1** above. Review of all the overtopping discharge rates that used different methodologies but with the same input conditions showed that the results derived are very variable (refer to **Appendix J** for further detail).

The results were also tested for sensitivity to key input parameters, notably beach toe level and beach crest width and permeability factor (see **Appendix J**). Even small changes in these input parameters are found to alter the resultant overtopping discharge significantly to the extent that, depending upon the input parameter, the tolerable discharge limit may or may not be exceeded. This has important

implications for determining the SoP provided by the beach and depending on the change in beach profile before, during and after a storm, the SoP achieved will likely vary significantly. It suggests that the function of the gabions in maintaining the beach crest could be very important in determining the SoP during conditions of mild overtopping. However, the SoP could deteriorate very rapidly were the gabions to be damaged or displaced during the course of an event, in much the same way as crest lowering during an event impacts upon the SoP, as discussed above.

3.2.2 Use of Overtopping Analysis to Derive Trigger Levels

Despite the concerns about the reliability of the overtopping analysis, a range of crest height and crest width combinations were analysed in developing the 2010 version of this BMP (refer also to **Appendix J**). The purpose of this was to assess the potential implications of changes in either of these parameters for the SoP provided by the beach only and beach with gabions (refer also to **Table 3.1**). Overtopping calculations carried out to determine the current (2010) SoP of the shingle ridge using the EurOtop method did not include an input for crest width. This is because the method does not include for this factor. Therefore, to determine the trigger crest width, overtopping analysis has been carried out using the W178 methodology for permeable rough revetments. This is the best available method for approximating the dimensions and performance of the shingle beach.

Tables 3.2, 3.3 and 3.4 summarise the results of this analysis in terms of the SoP achieved for a range of crest height and crest width combinations. When viewing these results, it should be borne in mind that much uncertainty remains about the rates of overtopping achieved along this frontage (and therefore the resultant SoP), as analysis for this study and review of previous studies (using different methodologies) provide very different results. This means that the use of these values to provide robust evidence-based trigger levels is not likely to be viable at the present time. However, in a qualitative form these results show that narrowing of the crest width and/or the lowering of the crest height lead to a reduced SoP and so monitoring of these parameters to assess long-term trends will be able to allow assessment of whether (and how) the SoP is reducing over time. This also suggests that the SoP could potentially be achieved by having a wider beach crest but lower crest height. This may be appropriate to consider as part of any future study of options to replace the gabion mattresses and castles that builds upon the work done by Halcrow (2012), although the ability to alter the configuration of the gabions in such a way may well be limited by the lack of available space behind the beach.

Table 3.2 *Standard of Protection based on crest width and crest level in 2009 (Refer also to Appendix J). NB: values in **bold** are the present (2010) SoP based on the range of beach profile dimensions observed in October 2009 beach profile survey data.*

Crest Level (mAOD)	Crest width (m)								
	4	6	8	10	12	14	16	18	20
15	<10	10	20	100	200	200	200	200	200
14	<10	<10	10	20	100	200	200	200	200
13	<10	<10	<10	10	20	100	200	200	200
12	<10	<10	<10	<10	10	20	100	200	200
11	<10	<10	<10	<10	<10	10	20	100	200
10	<10	<10	<10	<10	<10	<10	10	20	100

Table 3.3 *Standard of Protection based on crest width and crest level in 2059 (refer also to Appendix J).*

Crest Level (mAOD)	Crest width (m)								
	4	6	8	10	12	14	16	18	20
15	<10	<10	10	20	50	100	200	200	200
14	<10	<10	<10	10	20	50	100	200	200
13	<10	<10	<10	<10	10	20	50	200	200
12	<10	<10	<10	<10	<10	10	10	50	200
11	<10	<10	<10	<10	<10	<10	<10	10	50
10	<10	<10	<10	<10	<10	<10	<10	<10	10

Table 3.4 *Standard of Protection based on crest width and crest level in 2109 (refer also to Appendix J).*

Crest Level (mAOD)	Crest width (m)								
	4	6	8	10	12	14	16	18	20
15	<10	<10	<10	<10	10	10	20	100	200
14	<10	<10	<10	<10	<10	<10	10	20	100
13	<10	<10	<10	<10	<10	<10	<10	10	20
12	<10	<10	<10	<10	<10	<10	<10	<10	10
11	<10	<10	<10	<10	<10	<10	<10	<10	<10

3.2.3 Overwashing Analysis

In developing the 2010 version of this BMP, overwashing analysis was also carried out for the free-standing shingle barrier beach part of the BMP frontage (MU2 and MU3) using the method presented by Bradbury (2000). The input data for this analysis was the same joint probability extreme wave and water level input data used for the overtopping analysis, and the most recently available beach profile data from the regional coastal monitoring programme (October 2009 surveys from PCO). Additional analysis was undertaken using the HR Wallingford (1997) swell wave conditions with a water level equivalent to MHWS.

The results from this analysis suggest that the risk of a breach in MU2 and MU3 due to overwashing between beach profiles 6a00119 and 6a00184 under a 1 in 200 year (0.5% APO) storm event (based on the JPA data only – refer to **Section 2.3**), even in year 100 allowing for climate change impacts and sea level rise, is very low. However, this analysis is based upon the present day beach parameters which the analysis has assumed will be valid in year 100. This may not be the case and more detailed analysis could be undertaken to provide a more robust assessment of the risk of overwashing under different conditions. As with the overtopping methods discussed above, the method for overwashing analysis also does not take account of crest lowering during the course of an event and the resultant implications for the SoP.

For the swell wave conditions appraised, for the most part the risk of overwashing does not occur at the present time when using the MHWS water level. The exception to this is around profile 6a00155 where overwashing could occur under the conditions appraised for swell waves with a period of 18

seconds. Tests using the extreme still water levels show that overwashing is unlikely to occur until sometime in the future, allowing for the effects of sea level rise, and even then only when sea level rise is combined with high, infrequent (i.e. 1:100 year return period (1% APO)) water levels and wave periods of the order of 18 seconds (NB: wave periods of 14 seconds are not predicted to result in overwashing).

3.2.4 Summary of SoP Assessment

The overtopping analysis undertaken to develop the 2010 version of this BMP (see **Appendix J**) using locally generated waves indicates that the existing SoP based on an overtopping threshold of 0.1 l/s/m (for structural safety based on EurOtop Manual (Environment Agency, 2007)) for the shingle beach only section is 1 in 10 years (10% APO) along this frontage, and reduces to below this by year 50. This is in line with the findings of the *Strategic Flood Risk Assessment* (Royal Haskoning, 2006) as discussed above. However, when swell waves are considered the existing SoP based on the same 0.1 l/s/m threshold reduces to less than 1 in 1 year.

The existing SoP for the shingle beach with wave return wall section, calculated for the most recent beach profile dimensions and based on the overtopping discharge for public safety (0.1 l/s/m) using locally generated wave conditions, varies from greater than 1 in 200 years (0.5% APO) in 2009 to 1 in 10 years (10% APO) in 2109. In terms of structural safety, using the overtopping discharge limit of 50 l/s/m for structural safety, the SoP is predicted to be greater than 1 in 200 years (0.5% APO) for the next 100 years, a finding also replicated when swell waves are considered using the most recent beach profile dimensions. This is in disagreement with the findings of the *Strategic Flood Risk Assessment* reported in the *Chesil Beach Management Plan Scoping report* (Environment Agency, 2009a) although the reasons for this are not clear (it may be due to different methods of analysis).

Comparison with previous studies, and tests on the sensitivity of the results to even small changes in one or two input parameters, demonstrated that the resultant overtopping discharge rate, and so the assessment of the SoP, is highly sensitive, particularly to the level at which the beach toe is defined or the beach crest width is at a given moment in time. One thing the analysis of swell waves does show, however, is that **compared to the locally generated wave conditions the swell waves present a much greater potential overtopping discharge and thus flood risk.**

Based on the analysis, the risk of overwashing occurring during a storm event with short-period waves even under a 1 in 200 year return period (0.5% APO) event in year 100 is considered to be low. However, there is a much greater risk of overwashing for longer-period swell wave events when the period is around 18 seconds. The analysis undertaken suggests that one part of Chesil Beach around profile 6a00155 is vulnerable to overwashing should such an event coincide with a water level of about MHWS. The risk of overwashing is dependent on the geometry of the beach and the risk along other parts of the beach is thought to be low. **The risk of overwashing will increase as sea levels rise, particularly when swell wave events occur with a period of about 18 seconds or more.**

Overall the overtopping and overwashing analyses give very different predictions of SoP and how it may alter in the future. The reasons for this are likely due to the different ways in which each method represents the interaction of wave, water level and beach parameters, although **more research in this area is required** (refer also to **Section 1.4.1.1**).

3.3 Trigger Levels

Trigger levels are an important tool for operating authorities to quickly assess the requirement for works to the beach and/or defence structures without the requirement for detailed topographic surveys of the beach. Typically there are two trigger levels that are defined; the **Action Level** and the **Crisis Level**.

These levels are typically related to defined beach dimensions such as crest height or crest width resulting from understanding of the impacts of changes in such dimensions on the SoP derived from overtopping analysis. However, as discussed in **Sections 1.4.1.1 and 3.2**, there are significant uncertainties in the assessment of SoP along this BMP area that mean it is not possible now to provide robust evidence-based trigger levels (based on assessment of changes to the SoP).

Therefore, the Action and Crisis Levels defined in this BMP to guide when works should occur over the next 5 years primarily formalise practices that have been carried out by the EA Operations Delivery Team in the recent past (refer also to **Section 1.4.1.2**). These levels can then be revised when the BMP is reviewed in 5 years' time, when more data is expected to be available to inform management decisions. Then it may be possible to derive further trigger levels based upon assessment of changes in the SoP.

The application of trigger level values should not be absolute, and consideration should also be given to sea conditions at the time of the assessment. The best opportunity for beach inspections is immediately following a storm event. However, whilst the beach usually experiences significant draw-down and even crest width reduction during storms, the lower part of the beach usually recovers to near its pre-storm level shortly afterwards in calmer conditions (but the upper part of the beach towards the crest can take much longer to recover). **It is therefore recommended that unless further severe weather is expected, several days (4-5 days) should be allowed for the beach to recover following the storm before remedial actions to recover beach levels are implemented, unless there is the likelihood of catastrophic failure of the hard-defences if such a delay were taken.** In taking this approach of waiting several days, it is important to recognise that it is likely that only recovery of the lower part of the beach will be observed (if any) in this short time-frame; the upper part of the beach is likely to remain at reduced levels for a considerable period of time following the storm event. This is based upon experience following the winter 2013/14 storms.

3.3.1 Management Unit 1 (MU1) Trigger Levels

In MU1, the beach level against the Environment Agency operated sea wall should be no more than 1.5m from the wall crest in order to ensure the recurve of the wall operates effectively and prevents waves running up over the wall.

In addition, the beach level in this area should also not fall below a level at which the toe of the defence is at risk of being exposed. The exact toe levels of these defences are shown on the scheme drawings (**Appendix I.2** and **Appendix I.3**). In summary, the Action Levels are to be 1m higher than the toe level as follows:

- For the section of re-curved wall with stepped revetment fronting it in MU1 (i.e. between the 2014 toe protection and the gabion castle), the Action Level is approximately

+5.1mOD. This is equivalent to the top of the 5th step of the revetment (counting from the top) being visible (see **Figure 3.7**).

- For the section of wall fronted by the new toe protection added in 2014 (i.e. between the West Weares wall and the stepped-revetment), the Action Level is approximately +4.1mOD. This is equivalent to the top of the steel sheet piling of the toe protection being visible (see **Figure 3.8**).
- For the WPBC wall at the south-eastern end of MU1, the Action Level would be about +3.0mOD. For the West Weares wall this is about equivalent to the point where the top of the steel sheet piling will be visible at the base of the concrete wall. For the section between the West Weares wall (see **Figure 3.9**) and the new 2014 toe protection structure, this is equivalent to three full concrete panels being visible from the top of the seawall below Quiddles café (see **Figure 3.10**).

The Crisis Level would be approximately 1m lower than these Action Levels, at the point where the toe of the defence structure is exposed and the risk of undermining begins to increase.

It should be noted that at the far south-eastern part of MU1, the beach level fronting part of the WPBC wall is lower than these trigger levels. It is not possible to retain adequate beach levels in this far corner to reduce the risk of undermining; possibly due to wave reflection resulting from the orientation of the wall in relation to predominant wave direction causing any sediment that is deposited to be rapidly moved away.



Figure 3.7 Part of the stepped revetment with all five steps showing (taken 9th February 2014, courtesy of A. Frampton).



Figure 3.8 The new 2014 toe protection structure in MU1 with top of steel sheet piling visible (taken 29th August 2014, courtesy of A. Frampton).



Figure 3.9 Top of the steel sheet piling along the West Weares wall (taken 29th August 2014, courtesy A. Frampton).



Figure 3.10 Concrete panels below the wall crest along the part of the wall below Quiddles café (taken 29th August 2014, courtesy A. Frampton).

3.3.2 Management Unit 2 (MU2) Trigger Levels

In MU2, the beach level against the gabion castle and gabion mattresses should not fall to less than 1m above the toe level of these structures to reduce the risk of undermining. The exact toe levels of these defences are shown on the 2014 repair scheme drawings (**Appendix I.4**). In summary the Action Levels in MU2 are as follows:

- The Action Level in the area of the gabion castle is approximately +6.0mOD. This is about equivalent to five gabion baskets being fully exposed below the level of the adjacent seawall/promenade (see **Figure 3.11**).
- The Action Level along the length of the gabion mattresses is between +9.0 to +11.0mOD, depending on the specific depth of the gabions along different parts of the beach in this MU2. This is equivalent to the two top mattress layers and the upper part of the third (bottom) mattress layer being fully exposed on the seaward (Lyme Bay) side of the mattresses (see **Figure 3.12**).

The Crisis Level would be approximately 1m lower than these Action Levels, at the point where the toe of the defence structures is exposed and the risk of undermining begins to increase.



Figure 3.11 View of the gabion castle with one and a half gabion baskets exposed below the level of the adjacent wall/promenade (taken 29th August 2014, courtesy A. Frampton).

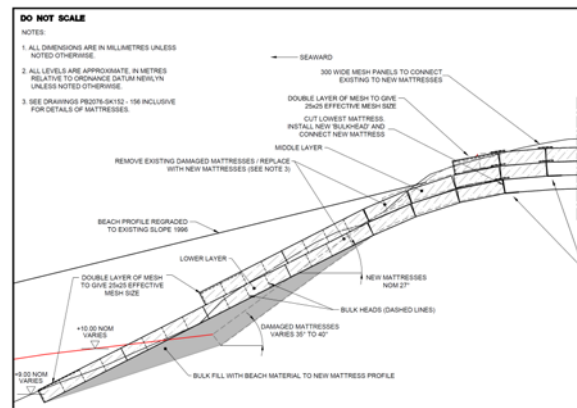


Figure 3.12 Part of drawing showing mattress layers re-built in 2014 (from Appendix I.4).

In addition to reducing the risk of undermining, works are also required to ensure that 300mm of shingle are retained on top of the gabion mattresses. Therefore a further trigger level in MU2 is to be the depth of shingle over the gabion mattresses. However, it is known that towards the gabion castle this is not possible to achieve as the beach profile is too steep and shingle just falls off.

Triggers to push material back up the back slope of the beach to the crest in the vicinity of the Masonic Car Park (where it is pushed down the slope by beach users accessing the beach from the car park) within this MU2 should continue to be based upon visual inspection, and do not require a trigger level to be set. *Note, this is not a trigger to move beach sediment from the back slope to the front slope on the Lyme Bay side, which is not to occur under any circumstances.*

3.3.3 Management Unit 3 (MU3) Trigger Levels

In MU3 no routine maintenance is to be carried out and therefore trigger levels are not defined. Works here would only be considered if the defence function of the beach is compromised as a result of a large wave event. No data is available to begin to define what such an event may look like and so such works would need to be based upon expert judgement on site should an event occur.

The only Action Level trigger that can be defined now relates to the flood alleviation channel profile (i.e. the channel between 'The Windows' and the 'Portland Harbour Culvert'). This channel has a design profile and works should be carried out to maintain this profile as required, as modelling work by CH2M HILL (2014b) indicates that a reduced capacity in this channel increases flood depth and flood extent in an extreme event. It should be noted that it is the view of the EA Operations Delivery team that the current channel profile is approximately the design profile. The design profile is shown on scheme drawings (refer to **Appendix I.2**) and a typical cross-section is provided in **Figure 3.13**, but no routine monitoring of this is currently undertaken.

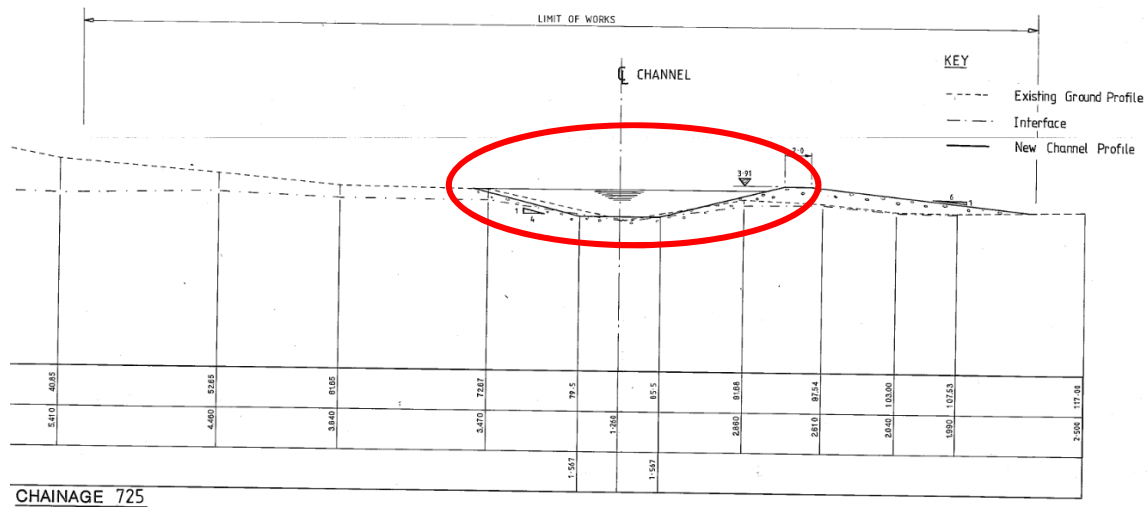


Figure 3.13 Typical cross-section of the channel between 'The Windows' and the 'Portland Harbour Culvert' (refer to Appendix I.2 for further details).

3.3.4 Trigger Levels Summary

For ease of future reference, **Table 3.5** summarises the 'Action' and 'Crisis' levels defined for the BMP area.

Table 3.5 **Summary of trigger levels.**

Management Unit	Sub-Section Description	Action Level	Crisis Level
MU1	Section of re-curved wall with stepped revetment fronting it in MU1	approximately +5.1mOD <i>[equivalent to the top of the 5th step of the revetment (counting from the top) being visible]</i>	approximately +4.1mOD
	Section of wall with toe protection added in 2014 fronting it in MU1	approximately +4.1mOD <i>[equivalent to the top of the steel sheet piling of the toe protection being visible]</i>	approximately +3.1mOD
	WPBC wall at the south-eastern end of MU1	approximately +3.0mOD <i>[equivalent to (a) the point where the top of the steel sheet piling will be visible (West Weares wall) and/or (b) three full concrete panels being visible from the top of the seawall (below Quiddles café)]</i>	approximately +2.0mOD
	All re-curved walls	Beach crest height to be at least 1.5m below wall crest height	-
MU2	The area of the gabion castle	approximately +6.0mOD <i>[equivalent to five gabion baskets being fully exposed below the level of the adjacent seawall/promenade]</i>	approximately +5.0mOD
	Along the length of the gabion mattresses	between +9.0 to +11.0mOD, depending on the specific depth of the gabions along the length of the defence <i>[equivalent to the two top mattress layers and the upper part of the third (bottom) mattress layer being fully exposed]</i>	between +8.0 to +10.0mOD, depending on the specific depth of the gabions along the length of the defence
	Along the length of the gabion mattresses	Depth of shingle over the gabions falls to less than 300mm (or the gabion mattresses become exposed at any point).	-
MU3	Flood Alleviation Channel (Monsoon Drain)	Infilling of channel with shingle pushed in by percolation events (that form 'canns') reduces channel capacity from design profile.	-

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Over the next 5 years, a comprehensive monitoring programme is recommended to be undertaken in order to provide a greater level of quantitative field data. This will aid improved understanding of the coastal processes operating at the south-eastern end of Chesil Beach, as discussed in **Section 1.4.4**. This improved quantitative data may also allow improved application of analytical techniques by providing more information with which to test existing and/or develop new methods.

The following sections discuss the recommended monitoring requirements over the next 5 years with this objective in mind. In doing so, it incorporates the ongoing monitoring undertaken by the Plymouth Coastal Observatory (PCO) as part of the South-West Regional Coastal Monitoring Programme (SWRCMP), who already carry out two annual beach profile surveys (and post-storm surveys when needed), a 5-yearly bathymetry survey, have a wave buoy deployed offshore of the BMP area at about the -10mCD bathymetry contour (refer to **Section 2.1**), and undertake aerial LiDAR and aerial photography surveys on a frequent basis. **The continuation of this monitoring programme is vital to improving the understanding of the coastal processes that lead to coastal flood and erosion risks along the BMP area.**

4.1 Beach Monitoring

4.1.1 Beach Profile Survey

Topographic beach profile surveys are carried out by the PCO as part of the SWRCMP every Spring and Autumn. Profiles are taken at pre-defined locations within the management unit (see **Figures 4.1a to 4.1d**). Quality controlled data is freely available online via www.channelcoast.org. PCO and/or the Environment Agency also undertake post-storm surveys along a sub-set of these regular survey locations (refer to **Section 2.6.4**), although not all storm events result in post-storm surveys being triggered.

Table 4.1 provides a summary of the beach profile locations used for regular monitoring along the BMP area, including beach area descriptions and origin co-ordinates. Within **Table 4.1**, the last 3 digits of the location ID are highlighted in bold. These correspond to markers along the frontage placed in the summer of 2015 to allow ease of identification during walkover inspections and beach re-cycling events in the future.

To aid efforts to improve coastal processes understanding (refer to Section 1.4.4), it is recommended that regular monitoring of beach profiles be extended further to the north-west of the BMP extent as far as Abbotsbury.

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Table 4.1 Beach profile locations surveyed by PCO on a twice-yearly basis. NB: profile lines used for post-storm surveys are highlighted in yellow.

BMP Management Unit	Profile ID	Easting	Northing	Used for Post-Storm Surveys?
MU1	6a00109	368495.050	73157.650	No
	6a00110	368504.010	73206.580	No
	6a00111	368496.020	73260.850	No
	6a00112	368483.100	73307.480	No
	6a00113	368470.940	73360.180	Yes
	6a00114	368445.010	73416.980	No
	6a00115	368410.100	73457.770	No
	6a00116	368381.010	73496.980	No
	6a00116a	368344.11	73553.56	No
	6a00117	368323.910	73555.120	No
MU2	6a00118	368306.980	73573.030	Yes
	6a00119	368281.010	73631.980	No
	6a00120	368269.030	73679.960	No
	6a00121	368254.920	73732.100	Yes
	6a00122	368246.960	73755.050	No
	6a00123	368205.970	73775.030	No
	6a00124	368183.950	73840.050	Yes
	6a00125	368157.010	73889.990	No
	6a00126	368124.890	73925.130	No
	6a00127	368068.990	73936.010	No
	6a00128	368078.010	73993.990	No
	6a00129	368050.990	74037.010	No
MU3	6a00130	368031.980	74079.030	Yes
	6a00131	368018.910	74128.100	No
	6a00132	367993.040	74129.950	No
	6a00133	367959.970	74166.040	No
	6a00134	367920.020	74200.980	No
	6a00135	367892.190	74241.090	No
	6a00136	367882.010	74258.990	Yes
	6a00138	367833.010	74317.990	No
	6a00139	367795.950	74358.060	No
	6a00140	367769.970	74393.030	Yes
	6a00141	367736.000	74436.000	No
	6a00142	367694.990	74475.010	No
	6a00143	367675.010	74503.990	No
	6a00144	367654.070	74524.920	Yes
	6a00145	367624.010	74555.990	No
	6a00146	367591.970	74582.040	No

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BMP Management Unit	Profile ID	Easting	Northing	Used for Post-Storm Surveys?
	6a00147	367551.990	74620.010	No
	6a00148	367517.990	74658.010	Yes
	6a00155	367261.990	74899.010	No
	6a00161	367110.070	75164.930	No
	6a00166	366996.010	75370.990	No
	6a00172	366853.960	75647.050	No
	6a00178	366671.440	75874.650	No

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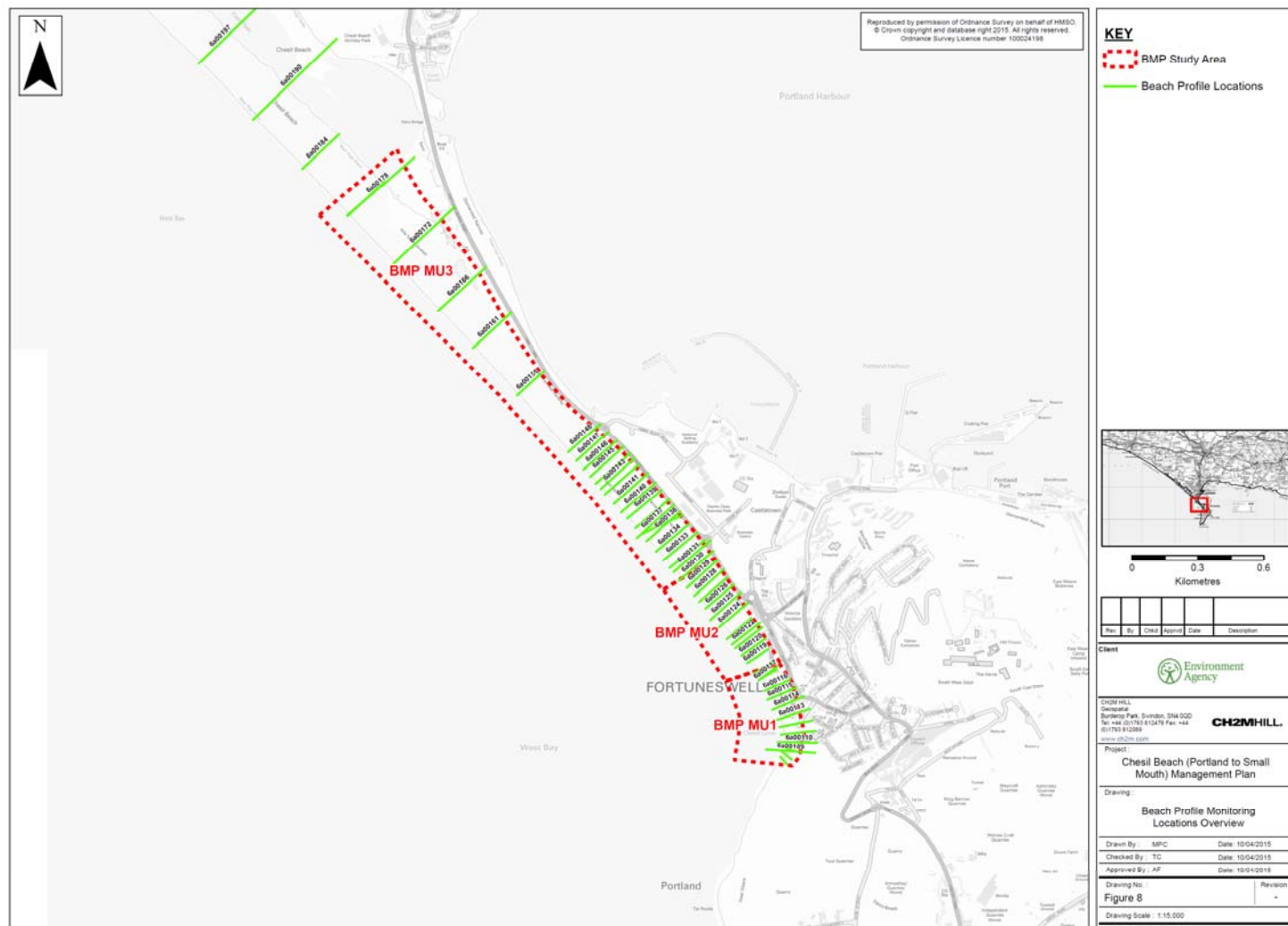


Figure 4.1a Beach profile survey locations along the BMP area (overview).

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Figure 4.1b Beach profile survey locations along BMP MU1.

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Figure 4.1c Beach profile survey locations along the BMP MU2.

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Figure 4.1d Beach profile survey locations along the BMP MU3.

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Analysis of beach profile data is undertaken by PCO and reported annually. In addition to this annual reporting, **the monitoring and routine reporting on additional beach parameters, such as beach plan shape, crest level and crest width above given threshold level (as demonstrated in Sections 2.5.2 and 2.5.4 of Appendix E) should also occur after each survey** (refer to **Section 4.6**). This will allow trends in these parameters to be identified as the data record grows. These additional parameters can be derived from data already collected as part of the regional coastal monitoring programme and could be included in future PCO annual reports.

Additionally, the flood alleviation channel between the two gabion culverts at either end in MU3 (i.e. the channel between 'The Windows' and the 'Portland Harbour Culvert') has a design profile and this is shown on scheme drawings (see **Appendix I.2**). **Occasional surveys of the channel should be undertaken to monitor the channel profile in relation to the design profile** as this is a trigger level defined in **Section 3.3.3**. The need for a survey should be triggered by visual inspection.

Additional post-storm surveys are to be undertaken as required to capture more data on the effects of storm events. There is uncertainty about how these post-storm surveys are triggered and whether or not data is being obtained following relevant storm events that cause an impact on the BMP area. Changes to how post-storm surveys are triggered could therefore be made – perhaps making use of additional visual information from those on site such as the Chesil Beach Warden who has previously recorded details of storm events (Moxom, 2009), the flood bailiffs, EA Operations Delivery team or CCTV images. Additionally the Flood Warning Duty Officer is responsible for initiating post-storm reconnaissance after each flood warning event, although this is currently only concerned with recording extent and impact of flooding and does not extend to calling out post-storm beach profile surveys. **These changes should be explored and mechanisms put in place for allowing those on site who agree to take on this role to request post-storm surveys be undertaken.**

Pre-storm surveys could also usefully be undertaken if a forecast storm event is thought likely to result in significant impacts on the beach morphology. These pre-storm surveys could be triggered by the Flood Incident Duty Officer as part of the procedures for issuing flood warnings (refer to **Section 4.5.1**). Capturing pre-storm surveys as well as post-storm surveys will improve understanding of how the beach responds to storms, and could be better related to wave, tide and beach water level data.

As an interim measure, until more data is available to refine understanding, **it is recommended that pre-/post-storm beach profile surveys be triggered by the Environment Agency when an event occurs (or is forecast to occur) whereby the following levels will be met/exceeded:**

- **Wave period = 12s or greater.**
- **Significant wave height = 5m or greater.**
- **Tide levels at Weymouth = 1.8mOD or greater.**

4.1.2 Master Profile Survey

There is much uncertainty about the precise volume of shingle on Chesil Beach as a whole with estimates ranging from 15Mm³ to 65Mm³. This uncertainty is a result of a lack of understanding of where the sub-strata on which Chesil Beach sits is located beneath the beach.

Although definition of the definitive master profile is not essential at this time for assessing trends in beach volume change as changes are referenced to a defined assumed master profile. Therefore this task could be the subject for more academic research in the coming years but not form a requirement of the monitoring programme in the next 5 years, and this could potentially be achieved in a number of ways, such as:

- Undertaking a penetrative survey or using new methods such as Ground Penetrating Radar (if range of depth penetration improves) to identify the level of the underlying bed layer that, in turn, will provide a definitive 'Master Profile' for use in beach profile analysis and will allow more accurate estimates of beach volumes to be made.
- Undertake a review of all survey data captured following the 14th February 2014 storm event (both topographic and terrestrial laser scan data), which exposed the bed rock in the south-easternmost part of MU1 (refer to **Figure 1.11** above), to determine bed levels for this area that can then be assumed for the other parts of the BMP extent (in lieu of any other information) to provide a more accurate master profile.

4.1.3 Beach Recycling Logs and Survey

During maintenance works undertaken to recycle beach material along the beach and to re-profile the beach (see also **Section 5**) **beach recycling logs will need to be maintained** by Environment Agency operations staff. This information will allow future analysis of beach volume changes to account for beach recycling and re-profiling work and will enable the underlying natural beach movements to be identified.

A template of the beach recycling log to be used is provided in **Appendix K** of this BMP. It is to be completed in a simple manner, by tallying the number of truck loads (of known capacity) transported along the beach during a maintenance period.

In order to validate the beach recycling logs, **it is recommended that two separate beach surveys, 'in' (pre-recycling) and 'out' (post-recycling), are undertaken for the first few beach recycling campaigns**. This will allow a relationship to be established between the information recorded on the beach recycling logs and the changes in beach profile. Such information will improve confidence in the accuracy of future beach recycling logs when no pre-recycling and post-recycling surveys are conducted. The Environment Agency should ensure that these surveys are compliant with the standards used in the SWRCMP.

4.1.4 Bathymetric Survey

Routine bathymetric surveys are to continue in line with the schedule determined by PCO. The next bathymetric survey for Lyme Bay in the area of Chesil Beach has not yet been programmed.

In addition, given the changes in seabed observed as a result of the winter 2013/14 storms, and to further the understanding of the beach/nearshore system (refer to **Section 1.4.4**), **it is recommended that multi-beam bathymetry surveys be undertaken following any future storm event that causes changes to Chesil Beach in a similar way to that experienced as a result of the winter 2013/14 storms** (refer to **Section 1.3.1** and Section 7.4 of Appendix E). In such situations, multi-beam bathymetry survey should be undertaken as soon as possible after the event to capture nearshore changes to the seabed levels and sediment composition. The extent of survey should be at least the same as that shown in Figure 7.8 of **Appendix E**.

4.1.5 Sediment Sampling

As discussed in **Section 2.7**, percolation through the beach is an important issue in relation to both beach morphology and flood risk.

Information on changes in beach grading and sediment size both on the beach surface and the core of the beach would aid understanding of how beach porosity impacts upon beach morphology changes in combination with the prevailing wave, wind and tide conditions. This would also help to aid understanding of how the relationship between these parameters relates to flood risk and so could aid improvements in understanding when flood warnings are issued (refer also to **Section 4.5.1**).

This could involve physical excavation of areas of the beach to gather samples for sieving, although less intrusive methods using photogrammetry methods and computer software packages to undertake 'visual' assessments such as recently completed by the University of Loughborough in 2015 (refer to **Section 2.5.1**); or even ground penetrating radar techniques; may be more practical to implement on a repeat basis. This task is very much a high level research topic at the current time and therefore could be the subject for more academic research in the coming years, but not form a requirement of the monitoring programme in the next 5 years.

4.1.6 Walkover Survey

The Environment Agency Operations Delivery team currently make use of visual inspections based on experience to determine when works are required. This includes judgement on the beach level against the seawall as it is important not to allow the beach level to be so high as to reduce the effectiveness of the re-curve on the seawall.

Visual walkover inspections should therefore continue to be undertaken by the Environment Agency to monitor beach crest level against the seawall, as well as depth of shingle over the gabions and if any infilling of the flood alleviation channel is evident. One walkover survey should be undertaken every month during the winter (October to March) and one survey every two months during the summer (April to September). Throughout the year, additional walkover surveys will need to be carried out prior to and immediately after storm events, as required.

Visual inspection of these parameters is required to allow use of the trigger levels identified in **Section 3.3**. To aid the visual inspection, particularly in MU1 where the seawall is present, markers defining the distance from the wall crest could be marked on the seawall.

4.1.7 Video Monitoring

The Environment Agency maintains a CCTV camera situated at the coastguard lookout in MU1 (see **Figure 1.10**). The information from the camera is used informally by the Environment Agency Flood Incident Management Team during storm events to help determine the need for flood warnings.

4.1.8 Aerial Photography and LiDAR

Aerial photography is flown every 5 years and LiDAR surveys are flown every 2 years by the Environment Agency on behalf of the SWRCMP. This data is made available online via www.channelcoast.org.

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Additional data, such as extra LiDAR and aerial photography captured of certain parts of the coast following storms in winter 2013/14, may also be available from the Environment Agency Geomatics team directly.

Continuation of these various planned and reactive post-storm aerial photography and LiDAR surveys, combined with regular monitoring of beach profiles (refer to **Section 4.1.1**), will allow future derivation of long term trends and recession rates. In doing so, **it is recommended that coverage of both extends the full length of Chesil Beach from Portland to Abbotsbury**. In time this will help to address the issue that currently exists in terms of the lack of long term data and understanding of interactions along the shoreline between the BMP area and the wider Chesil Beach (refer to **Section 1.4.4**).

Aerial photography could also be of use to assess the effect of recycling/re-profiling and/or storm events on the designated features of the beach (refer to **Section 4.3**).

4.1.9 Groundwater Monitoring

As part of the 1980's scheme, piezometers containing water level measuring instruments were fitted into three trial boreholes before they were backfilled (known as Boreholes). These are situated within MU2 and are used to monitor the saturation of the beach at a cost of £150 per annum to The Crown Estate Commissioners (refer to **Section 1.6.3**). These boreholes have been constructed at roughly half way along, and perpendicular, to the buried culvert system and in a line across the beach. The first being on the landward side of the sheet pile wall, through the surfaces of the 'Masonic Hall' car park (BH3), the second and third bores were at the mid beach (BH2) and beach crest (BH1) respectively. The beach crest borehole (BH1) was replaced as part of the refurbishment works since the original borehole had become filled with sand (Environment Agency, 2009a). The details of the current borehole arrangements are provided in **Table 4.2** and shown spatially on **Figures 4.2a and 4.2b** in **Section 4.4.2**.

Table 4.2 **Borehole monitoring locations.**

Borehole location	NGR co-ordinate	Depth	Minimum level	Maximum level
BH1 Beach Crest	SY 6814 7375	15m	-1.0m AOD	+14.0m AOD
BH2 Mid Beach	SY 6817 7376	5m	+1.0m AOD	+6.0m AOD
BH3 Car Park	SY 6819 7377	5m	0m AOD	+5.0m AOD

In addition to the boreholes, ground water data is also recorded by an ultrasonic level transducer within the drainage culvert at the outfall. There is also a pressure transmitter at the outfall of the monsoon ditch (bridge) into Portland Harbour. These telemetry locations are also shown spatially on **Figures 4.2a and 4.2b** in **Section 4.4.2**. The signals and data from all the monitoring instruments are collected within a display cabinet in a small masonry building known as the Masonic Hall Control Kiosk.

Only telemetry data from the culvert is currently used to inform the decision of the Environment Agency to issue flood warnings. Up to date trigger levels associated with this telemetry are stated in the 'South Wessex Flood Warning Procedures Manual' which is kept in the Area Flood Incident

Management Room at the Environment Agency's Blandford office (refer to **Section 4.5.1**). Procedures to utilise information from the mid-borehole location and possibly the Portland Harbour location are currently being considered by the Environment Agency Flood Incident Management team in Blandford.

Continuation of this monitoring and recording of water levels within the beach and its saturation may feed in to future analysis of overtopping discharges and the SoP provided by the beach to improve understanding of flood risk, particularly if combined with improved understanding of the beach composition (refer to **Section 4.1.5**).

A possible area of research in the future may therefore be examining the relationship between beach water levels, beach sediment composition, wave (both locally generated and swell) and wind climate and tide conditions. Consideration should also be given to collecting water level data within the beach and how this varies. Any such research project should aim to improve understanding of these relationships and how they relate to flood risk.

4.2 Structure Monitoring

4.2.1 Visual Inspection

An annual visual inspection of all of the coastal defence structures along the BMP frontage should be undertaken. This should occur during the spring of each year to identify any issues so that subsequent completion of any maintenance works required can be completed prior to the busy summer period, thus avoiding impacting on the amenity use of the beach.

Visual inspections to monitor structures after storms should also occur, since damage to the structures is most likely to occur during storms.

Monitoring of the coastal structures should be, where possible, undertaken in combination with the visual walkover inspection of the beach as described in **Section 4.1.7**, particularly following storm events. Each inspection should be recorded in a consistent way in a defence inspection log (see **Appendix L**).

In particular, the following items should be checked as part of these inspections:

- Management Unit 1, MU1:
 - Visual checking of the beach level in front of the seawalls to ensure that:
 - the level of beach is not too high in relation to the wave return wall such that it could impede the wave return performance.
 - The sheet piling at the base of the seawalls is not exposed by low beach levels.
 - Visual checking of the seawalls structure should identify:
 - If any holes have developed in the face of the seawalls.
 - If there are any cracks or other defects evident in the secondary wave return wall and stone retaining wall at the back of the promenade at the West Weares end of MU1 (i.e. WPBC wall).
 - Any issues with flood gates.

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- If any holes have developed in the promenade onto of the seawalls.
 - If the promenade surfacing, hand-railing or access steps/ramps have any damage that could impact public safety.
- Management Unit 2, MU2:
 - Monitoring of the gabion castle and mattresses that provide protection to the beach crest is to occur as part of this visual inspection, and is to include checking of:
 - Abrasion, resulting , severing of gabion wires;
 - Tearing of liner and spillage of fill material;
 - Projecting edges of gabion wires or liner as a result of damage;
 - Excessive settlement of gabion mattresses;
 - Trip hazard to walkers;
 - Coverage of the gabions by at least 300mm of shingle (where possible);
 - Surplus mesh, wire, liner or capstone on beach to be removed; and
 - Undermining of gabion mattresses at their toe.

Monitoring of the gabions for the issues highlighted above will help to reduce the health and safety issues.

- Where the beach is backed by steel sheet piles with timber capping (particularly exposed along the Masonic Car Park), visual inspection monitoring of the sheet piles is to be undertaken, although only the exposed top part is likely to be of concern in terms of corrosion risk. This sheet piling extends along the back of the beach to 'The Windows' where the interceptor culvert drains out into the flood alleviation channel.
 - Between the Masonic Car Park and the gabion castle in MU2, the back of the beach is constrained by a number of walls. These walls are in varying states of repair and should be inspected to assess their safety and integrity as their failure would result in the back of the beach encroaching on the land behind. However, it is not certain who owns these walls although it is thought that some at least belong to WPBC; indeed signage on them belongs to WPBC. **The ownership of these walls should be confirmed in the immediate future such that future maintenance requirements can be planned.**
 - The interceptor culvert beneath the beach should be inspected annually (a confined spaces inspection) and after large flow events to check the integrity of the structure.
- Management Unit 3, MU3:
 - The flood alleviation channel and culverts occasionally become filled with sediment which requires removal. This is understood to be required about every 5 years or

so and should be checked as part of the visual assessment as these areas are not well covered by survey data (refer also to **Section 4.1.6**).

- The gabions and stone walls around the culverts at either end of the flood alleviation channel (i.e. 'The Windows' and Portland Harbour ends) should be checked for damage, including public safety issues such as those identified in relation to gabions in MU2 above.
- The Portland Harbour culvert should be inspected annually and after large flow events to check the integrity of the structure.

4.2.2 Detailed Inspection

In addition to the annual and post-storm visual inspections described in **Section 4.2.1**, **full structural inspections of the seawalls, gabion castle and mattresses, slope stabilisation measures, interceptor drain, flood gates and culverts along MU1, MU2 and MU3 should be carried out every five years.**

As with the visual inspections, in order to ensure a complete and consistent set of data is recorded as part of these detailed inspections, reference should be made to the relevant asset management plans as identified in **Section 1.7.2**. It is suggested that these inspections should include a photographic record of the structures at the time of the inspection and these should be kept with the inspection records for future reference.

4.3 Environmental Monitoring

The area covered by this BMP has many environmental designations for a range of features. **Monitoring of these features should be carried out to enable evaluation of any long-term effects that may (or may not) be caused by the beach management regime set out in this BMP, including assessment of the impacts of any works that occur.**

The environmental features of interest are primarily located in MU2 and MU3 and as such the following monitoring items relate to that part of the BMP area:

- Monitor the distribution and composition of perennial vegetation of stony banks (annual vegetated drift lines, perennial vegetation of stony banks, Mediterranean and thermo-Atlantic halophilous scrub);
- Pre and post-storm visual inspection of environmental features; and
- Pre and post-works (planned or post-storm) inspection of environmental features, especially in the vicinity of plant compounds such as that in the Masonic Car Park (refer to **Section 5.4.4**).

In addition, there are many historic environment features in the area (refer to **Section 2.8.8**) and visual inspections should also seek to identify any impacts on these features (or indeed if 'new' features are uncovered by storm events). In the event of impacts or new features being identified, then the Dorset Historic Environment Officer should be contacted (refer to **Appendix G** for contact details).

4.4 Physical Conditions

4.4.1 Sea Conditions

Wave climate is monitored by a wave buoy located approximately at the -10mCD contour offshore of Chesil Beach (refer to **Section 2.1**). This wave buoy was installed in 2007 and is maintained as part of the SWRCMP and live and archived data is available online via www.channelcoast.org.

Continued monitoring of wave climate from this device will provide ever more data to improve understanding of wave climate and beach response in the future. However, there are concerns that during very large events the wave buoy could drift or go 'offline' and so make data captured during such events less reliable (or unavailable).

In addition, tide levels for storm events at this site are based on records for West Bay, the nearest available and 'appropriate' site. However, it has been found that this is unreliable as it has been shown that there is a significant difference between tide levels at West Bay compared to those at the Portland end of Chesil Beach (by up to 0.6m) and that tide levels need to be recorded at Chesil Beach (refer to Section 3.1 of **Appendix E**).

It is not considered viable to install tide recording device at Chiswell and therefore, in order to improve the wave and tide level data available at this south-eastern end of Chesil Beach, a more appropriate course of action to improve understanding of the relationship in tide levels at Chiswell compared to West Bay, Weymouth Harbour and Portland Harbour (where tide levels are recorded) will be to **undertake a hydrodynamic modelling study** to better understand to achieve this purpose. This could form part of the work of more detailed investigations into coastal processes as recommended in **Section 1.4.4**.

Recording of this site specific data, in combination with additional monitoring of other parameters as discussed in the other parts of this section of the BMP, will aid improvements in the understanding of the relationship between these forcing parameters and the beach response. This will help to both improve understanding of the processes in this area as well as the basis on which flood warnings are issued.

4.4.2 Storm Events

The movement of material along Chesil Beach is significantly increased during storms as a result of increased wave action. In order to understand the effect of storm events upon the beach response, **details of the storm conditions (waves, winds and water levels) will need to be recorded** in support of the post-storm profile surveys (refer to **Section 4.1.1**) from the various telemetry devices shown in **Figures 4.2a and 4.2b**.

At the present time, data from the wave buoy at Chesil, via the www.channelcoast.org website, should be used for obtaining details of the wave conditions in the nearshore area. Additional information on the offshore wave climate should also be recorded from other data sources such as near real time data from the *National Data Buoy Centre* and the *Cefas Wavenet* websites. These websites provide data for a number of locations between the Atlantic and the English Channel that are relevant to Chesil Beach, and recording of this information will allow assessment of any linkages between offshore and nearshore wave climate to be made once a sufficient data set is collected.

Despite its limitations, the West Bay tide gauge data, available via www.channelcoast.org, should also continue to be used to record tide levels at the present time. However, data from the

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Environment Agency's Q-Pier tide gauge in Portland Harbour and the national tide gauge in Weymouth Harbour should also be recorded (refer to **Section 2.2.1**).

Local wind gauge data from the PCO Meteorological Station located on the WPNSA (refer to **Section 2.1.3**) should also be recorded from the www.channelcoast.org website, in particular it is important to record wind speed and direction as both can have a significant impact on flood risk.

This wind, wave and tide data should be recorded as part of the storm event record. This storm record should contain details of all storm events including the prevailing conditions (as discussed in this section), pre/post-storm surveys, water levels within beach and effects/impacts of event. Examples of how this has been done previously, and which could form the basis for future storm event records, are provided in **Appendix M**.

In addition to capturing the physical conditions and impacts of storm events, **the impacts of storm events also needs to be captured in terms of where and when flooding occurred and to what extent and what was impacts (e.g. properties flooded; roads closed etc).** This information should be captured through date/time stamped photographs, videos, flood reconnaissance reports, and media (including social media) reporting. The information should be recorded in an event log alongside the physical conditions information for each storm event, similar to those provide in **Appendix M** by way of example.

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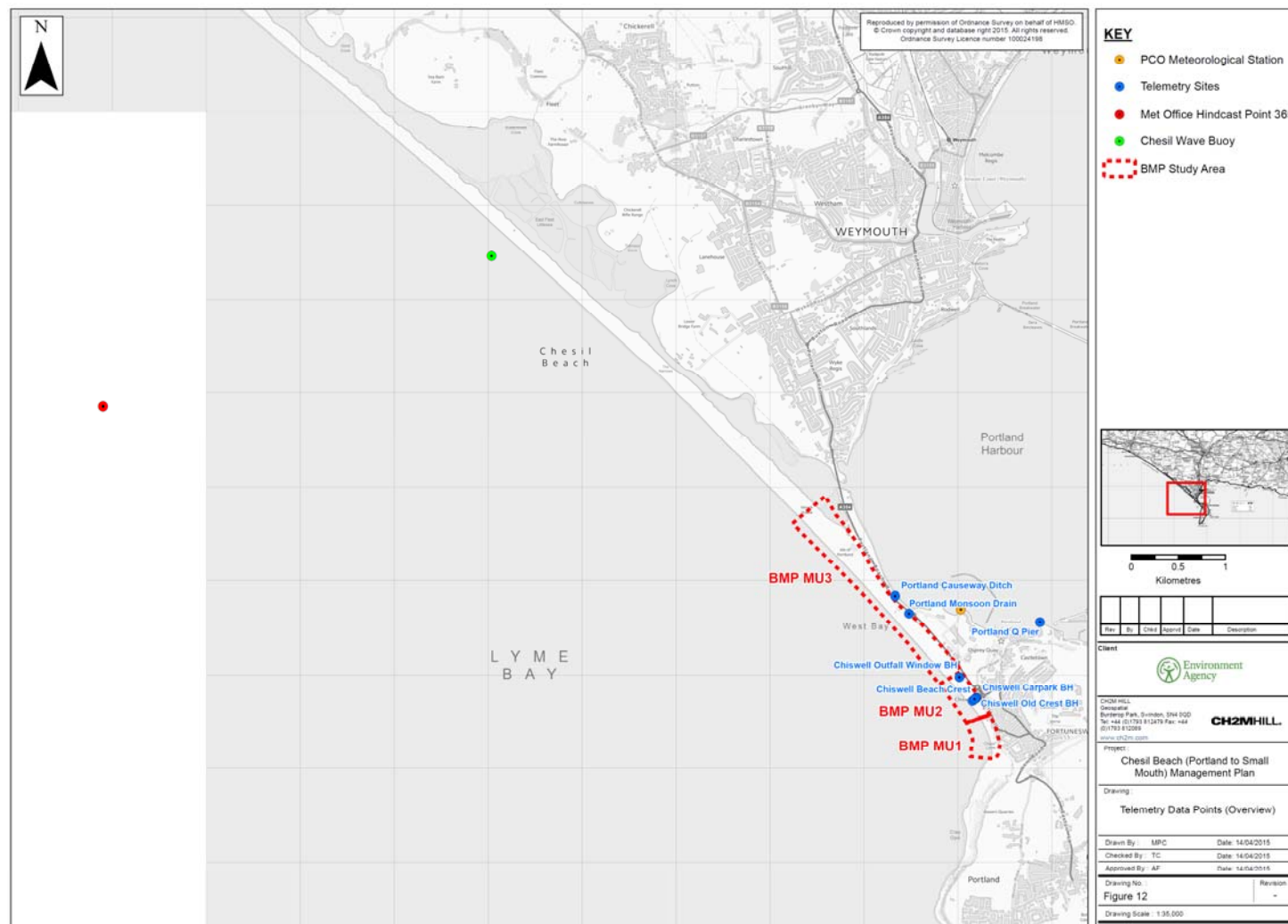


Figure 4.2a Telemetry Data Points (overview).

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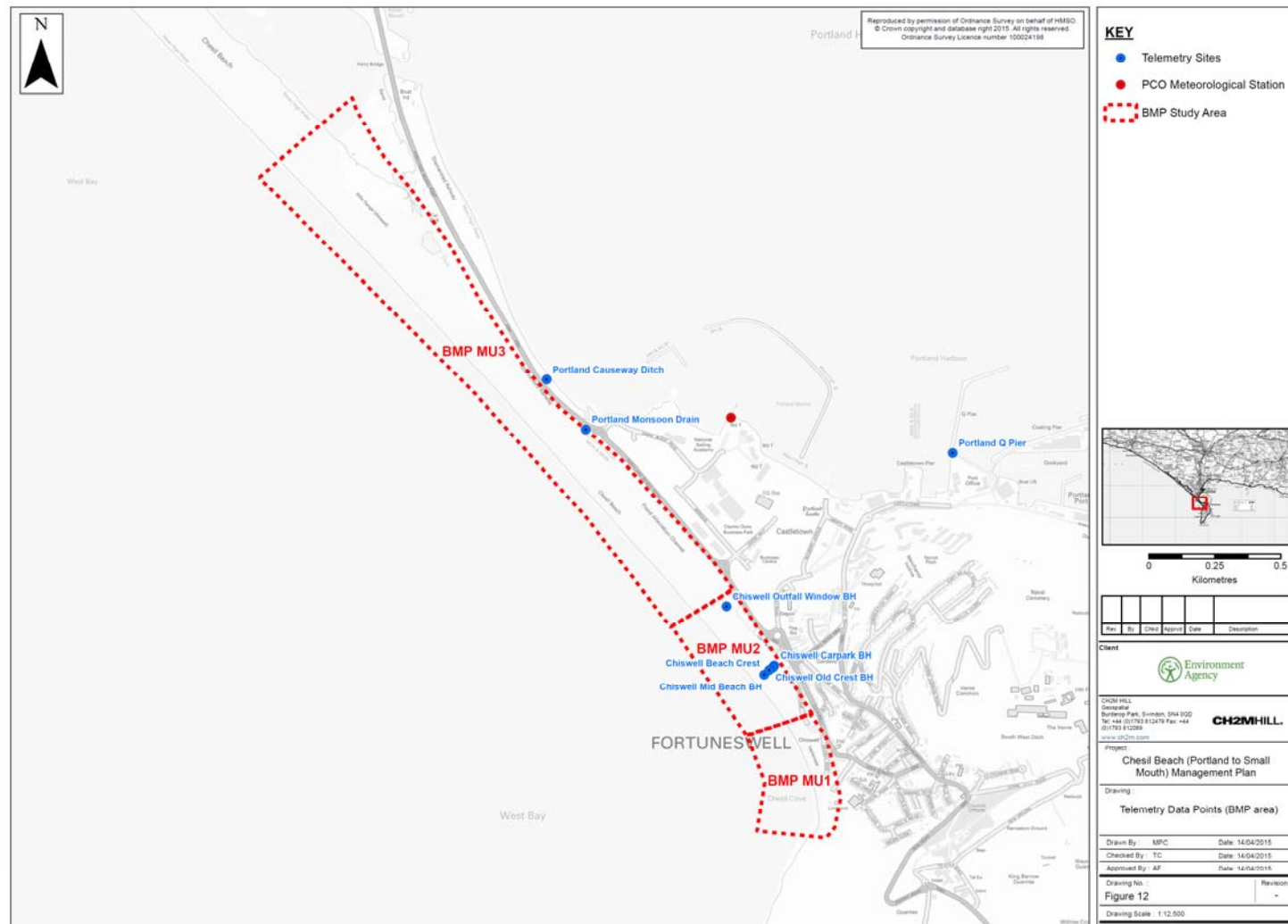


Figure 4.2b Telemetry Data Points (zoomed to BMP area).

4.5 Warning and Emergency Procedures

4.5.1 Flood Warning and Response Procedures

The following gives an overview of the Environment Agency's flood warning procedures applicable to the whole Chesil BMP site. Full details of the up-to-date flood warning procedures are to be found in the *Wessex South Flood Warning Procedures Manual*. The current procedures are kept electronically (*G:\Flood\Environment Management\Incidents and Emergencies\Flood Incident Management\Local Incident Procedures\Procedures\Issued\01 Database\Published Procs\index*) or in hard copy form in the incident room. They can also be accessed through the incident management toolbox.

Three levels of warning are issued: flood alert, flood warning and severe flood warning. A flood alert indicates that flooding is possible and is issued to professional partners, the flood bailiffs and members of the public who have requested to receive it:

- When a Flood Alert is issued, an operations delivery team attend the site, shut the gates in the defences and monitor the site. They are supported by the Flood Incident and Flood Warning Duty Officers who are based in the incident room. Monitoring takes place for two hours before the predicted high water and up to three hours after peak water.
- A Flood Warning indicates that flooding is expected. This warning goes to professional partners. The flood bailiffs and members of the public who are at risk. The community is registered on an "opt out" system.
- The Severe Flood Warning indicates that there is a risk to life. As well as the automated flood warnings there is a back-up siren which is sounded when damaging wave overtopping starts to occur.

Experience has shown that the post high water period is when the risk is highest.

The issuing of flood warnings by the Environment Agency is based upon a 3-way system of information:

- Forecast data from the National Flood Forecasting System (NFFS) including forecast wave height, swell period, wave direction, wind direction and total tide height. Wave data is much more important for flood warning at Chiswell than tide height.
- Onsite observations by Environment Agency Ops team and by flood bailiffs (and CCTV images).
- Telemetry/measured data, which currently consists of data from 'The Windows' outfall and boreholes in the beach.

Currently, flood warnings are based on the 'pre-conditions' for a large flood event being reached (i.e. high water level within the beach and large swell period waves from a certain direction range being forecast). Decisions are made based on a set of condition tables. These take into consideration forecast astronomical tide, wave height, swell period, wave direction, wind direction and total water level.

During the winter storms of 2013/2014 several flood warnings and severe flood warnings were issued. There was significant flooding on two occasions. Feedback from the community is that they are generally happy with the warning system and accept the need to adopt a precautionary approach.

Data gathered from the storms will be used to improve the accuracy of the warnings, including understanding of the lag between the time of high water and the time of maximum piezometric levels in the beach (refer to **Section 2.6.4**).

The greater level of monitoring set out in **Sections 4.1 to 4.4** of this BMP aims to provide improved information for understanding the whole beach system. In doing so, it is anticipated that this will also allow the relationship between certain water levels being reached and the associated consequences to be better defined to improve 'accuracy' of flood warnings. This will aid further the development of the recent detailed work on flood warning procedures for Chiswell (Royal Haskoning, 2010).

4.5.2 Landslide and Cliff Fall Response Procedures

Warning and response procedures for multi-agency working in relation to cliff fall and landslide risks at West Weares within MU1 of the BMP area, are defined in the *Dorset Coastal Rock Fall and Landslide Protocol* (Dorset County Council Emergency Planning Service, 2013; see also **Section 1.7.12**).

4.5.3 Pollution Incidents

Pollution incidents can occur at varying scales. Minor pollution such as litter and small debris are typically dealt with by WPBC. Larger pollution incidents are dealt with by Dorset County Council, guided by Section 4 of the *Dorset Coastal Pollution Clearance Plan* (Dorset County Council Emergency Planning Service, 2010; see also **Section 1.7.11**).

4.6 Data Storage and Analysis

Having collected the beach monitoring data, it is important that all of the information is stored and analysed to allow decisions to be made with respect to ongoing maintenance and future management of the south-eastern end of Chesil Beach covered by this BMP.

Following each scheduled twice-yearly beach profile survey and any intervening post-storm or other surveys completed by PCO or the Environment Agency, the information collected should be uploaded for storage and analysis to a database system that is compatible with that used by the SWRCMP and the Environment Agency – in this case CH2M HILL's SANDS software is used – and copied to the PCO/Environment Agency as appropriate.

After each beach profile survey, the Environment Agency should analyse the data to assess the range of beach parameters discussed in Section 4.1.1. The results of this analysis should be summarised in a brief beach survey report to include summary of profile changes, volume changes, plan shape/crest position, crest height, and crest width above a stated level (e.g. 10mOD contour). Assessment of beach level in relation to the trigger levels discussed in **Section 3.3** should also be undertaken in order to provide a record of the logic for undertaking further maintenance to the beach and/or coastal defences along the BMP frontage.

Additional beach monitoring data, obtained from sources such as the post-storm visual walkover inspections (with associated storm event data – see **Section 4.4.2**) or beach recycling logs (see **Section 4.1.3**), as well as information about the condition of structures (see **Section 4.2**) should also

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be stored in the same database. The database should include photographs taken during each survey.

This information should be used in compiling future annual beach monitoring reports such as those produced by PCO (examples of which are available from www.channelcoast.org).

5 MAINTENANCE REGIME

This section describes the maintenance regime that is necessary to ensure that the beach and defences along the BMP frontage continue to provide adequate coastal flood and erosion risk management of the area in the immediate future.

5.1 On-going Works

5.1.1 Beach

At present no regular beach maintenance works occur, but rather on a basis informed by a combination of visual inspection and beach monitoring surveys. This is to continue in the period to the next BMP review (in 5 years). As such, the undertaking of beach maintenance works is to be informed by the analysis of the results of the beach monitoring and the beach profile surveys undertaken in the spring and autumn of each year and following storm events, along with visual inspections (see **Section 4.1**).

The works that would occur as a result of these inspections would primarily be in MU1 and MU2 and are expected to involve the following types of works:

- Use of a mechanical excavator to reshape the shingle to the west of the gabion castle in MU2, primarily to push material back up the back slope of the beach to the crest to prevent it falling over into the land behind the beach. This is caused by footfall pushing material down the back slope as people access the beach on foot directly from the Masonic Car Park. *NB: sediment is not, and should not be, moved from the back slope of the beach to the front slope on the Lyme Bay side under any circumstances.*
- Use of a mechanical excavator to seek to cover the gabion mattresses in MU2 with a minimum of 300mm of shingle as a planning condition of WPBC. Keeping sufficient cover to the gabion mattresses should minimise the vandalism of the gabions that has previously occurred. It is known, however, that to achieve this coverage towards the gabion castle is not possible due to the angle of repose of the gabions, as the shingle just rolls off.
- Occasional works are needed in MU2 and MU3 to remove shingle from the culverts at either end of the flood alleviation channel. The requirement for such works is to be based on visual inspection and is to involve use of excavators to remove shingle deposited in the culverts and placing the material on the surrounding beach. An important consideration when undertaking these works is the need to minimise potential impacts on utilities beneath the beach, particularly in the area around 'The Windows' (refer to **Appendix D**). Utilities beneath the beach within MU2 and MU3 include sewer, water and gas. In 1989, the beach material was moved back up the beach for re-profiling using a series of stationary plant at different levels to 'pass material from one to the other up the beach' such that vibration impacts on the pipes was minimised. Vibration impacts on the gabion culverts should also be minimised when excavating these areas.
- Works to restore the design profile of the flood alleviation channel between the two gabion culverts at either end (i.e. the channel between 'The Windows' and the 'Portland Harbour Culvert') in MU2/MU3 are to be triggered by surveys and inspection (refer to **Section 4.1**). As with the culverts, excavated material is to be spread on the adjacent beach area and

works should seek to minimise impacts on structures and utilities beneath the beach in this area.

No other regular works would occur. Any other works would be triggered by the 'Action' and 'Crisis' levels (refer to **Section 3.3**) and these are discussed in **Sections 5.2 and 5.3**.

5.1.2 Structures

Routine maintenance works to the various coastal defence elements along the BMP frontage will be guided by ongoing inspection (refer to **Section 4.2**). **When either routine inspection or rapid assessment following a storm event identifies a defect in the defence, be it a crack in the defence or damage to public safety aspects of the defence (e.g. buckled hand railings or trip hazards etc.) then the following steps are to be followed:**

1. **Increased defect monitoring** – should any defects be identified then it may be appropriate to implement an increased level monitoring rather than immediately undertaking remedial works. This could also involve the use of additional monitoring devices such as crack gauges. This step would only occur if the identified defect is not considered an immediate safety risk (i.e. this step is optional and may or may not occur prior to Step 2).
2. **Remedial works** – once an identified defect is considered to be in need of remedial work, then the design of remedial works should be undertaken and an appropriate repair specification generated. To ensure consistent information on repairs undertaken is recorded, a defence repair record template is provided in **Appendix N**.

5.2 Action Level Works

The actions listed below should be enacted if the **Action Level** is reached along all or part of MU1 and/or MU2 (refer to **Section 3.3**).

5.2.1 Beach Recycling and Re-profiling

Should the beach level against the seawall crest height in MU1 be too high, as defined by the Action Level (refer to **Section 3.3**) then shingle should be moved from the upper part of the beach and spread over the rest of the profile in the middle to lower part of the beach.

If this accumulation of shingle in the upper part of the beach coincides with low beach levels in relation to the toe of the defence in other parts of the beach (i.e. within MU1 or MU2) then shingle should preferentially be placed in those areas and not spread over the beach as described above. However, at the far south-eastern end of the WPBC wall in MU1, it is not thought likely that recycling beach material to this area will be sustainable and that any material in this area will be transported away. The reason for this is thought to be due to reflection of waves caused by the angle of the seawall in relation to the prevailing wave direction. Future management of the beach in front of this part of the WPBC wall will therefore depend on future management decisions about the wall. **The Environment Agency should therefore continue to work with WPBC to ensure that the management of the beach is complementary to the management of the seawall.** As such, placing material in this south-easternmost end of the beach should be avoided even if beach levels are low. Rather material should just be pushed back down the beach slope in the vicinity of any accumulation where natural processes will move it around the system if beach levels along other parts of the seawall and gabions are satisfactory.

The other Action Level in MU1 and MU2 relates the beach level to the toe level of the defences (refer to **Section 3.3**). Should the beach level fall to the Action Level for each structure along MU1 or MU2, then the response should be to increase the frequency of survey and visual inspection to more closely monitor the situation and determine if there is a continuing trend of beach lowering in relation to trigger levels (and so identify if/when Crisis Level is reached), or if it is a temporary natural change.

In MU3, if monitoring finds that the flood alleviation channel or culverts is infilled then the procedures set out in **Section 5.1.1** should be followed.

5.2.2 Beach Recharge

From the assessment of coastal processes (refer to Section 2 and **Appendix E**) it is thought that this part of Chesil Beach is relatively stable overall. It is not thought that the volume of sediment along the frontage will significantly reduce over the next 5 years to the extent that recharge of the beach would be required. This position can be reviewed as part of the next BMP review in 5 years' time, which would also be able to utilise improved understanding of coastal processes that would result from the detailed review of coastal processes recommended in **Section 1.4.4**, supported by the monitoring regime defined in **Section 4**.

5.2.3 Structures

Action Level works will be re-active and based on visual inspection, and as such Action Level responses will follow the on-going works procedures defined in **Section 5.1.2**.

5.3 Crisis Level Works

If a **Crisis Level** (refer to **Section 3.3**) is identified as being reached on a profile, the immediate task would be to carry out a visual inspection of the profile concerned; firstly to validate the survey data and that it is representative of the general beach area around that location (i.e. not a localised 'low' point). If the **Crisis Level** is shown to be a general problem to be addressed, then timely action will be required to safeguard the integrity of the seawall and gabions.

The measures that should be considered once Crisis Levels are reached are recycling and re-profiling of sediment from other parts of the beach within MU1 and MU2 so long as to do so does not compromise the beach level in relation to the structures in those areas. The location from where to retrieve shingle for this purpose should be guided by a combination of beach profile survey (either routine or post-storm – refer to **Section 4.1.1**) and visual inspection.

The normal storm response of a beach involves the flattening of the front (seaward) slope as material is removed from the upper part of the beach and distributed further seaward along the profile (although some material may move alongshore also). As such, it is likely that material to be recycled in response to this Crisis Level will come from lower down the beach profile. If beach recycling is to occur in response to a Crisis Level being reached, then an informed discussion may be required between Environment Agency staff and officers of Weymouth & Portland Borough Council as to whether the priority area for placement of material should be along the toe of the gabion castle and mattresses in MU2 or the toe of the seawall in MU1. Movement of beach shingle to the south-easternmost end of MU1 should be avoided for the reasons stated in **Section 5.2.1**. When placing material, a terraced profile such as that illustrated in **Figure 5.1** be adopted as experience from the winter 2013/14 emergency response works suggests this provides a more stable beach shape and

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so protection, particularly to the gabions in MU2. This terracing will eventually be re-shaped by natural processes over a period of days to months, particularly on the lower part of the beach slope.

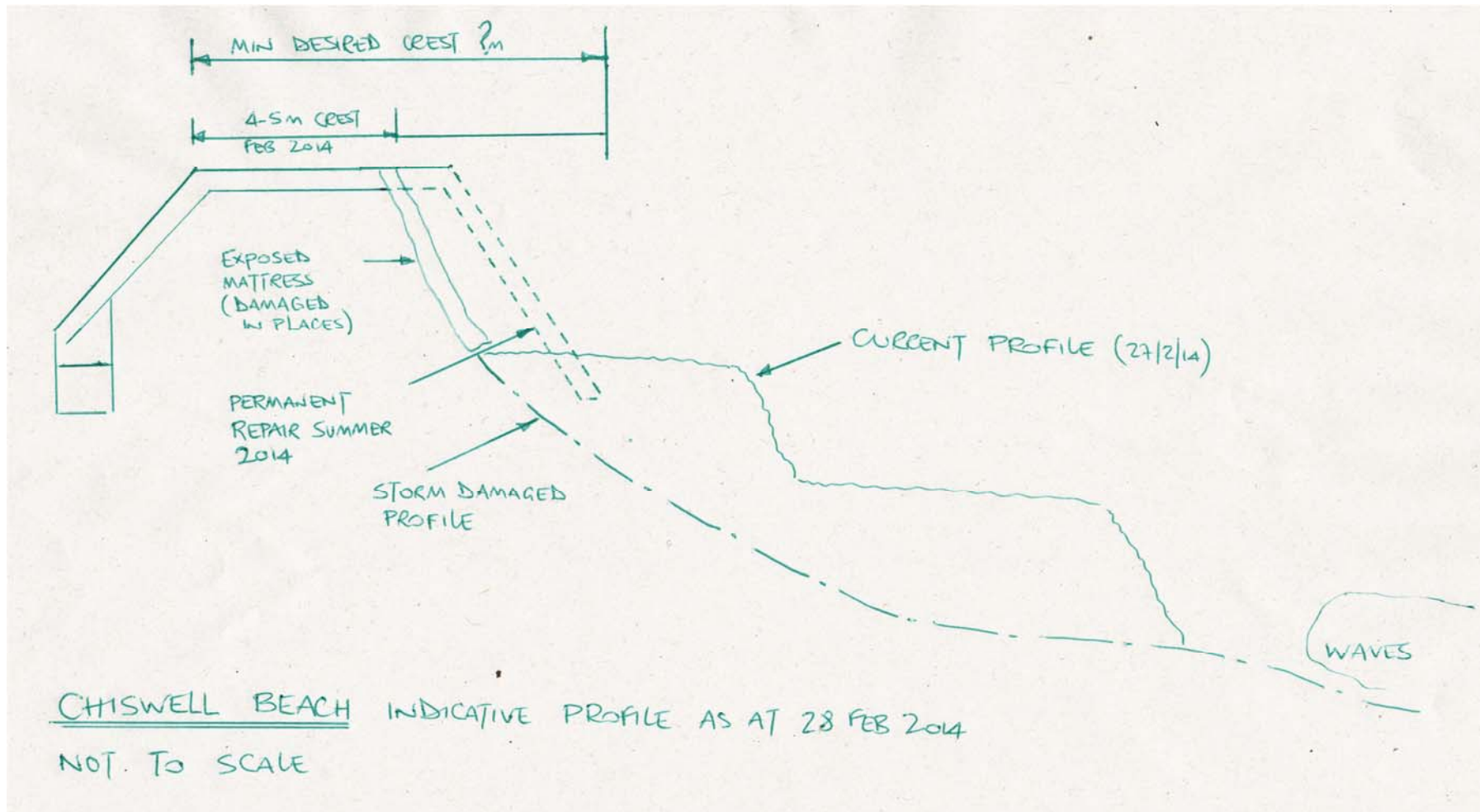


Figure 5.1 Illustration of profile terracing to be adopted during Crisis Level works (illustration developed during winter 2013/14 emergency response works).

Whilst the above addresses the risk of undermining of the seawall and gabion structures in MU1 and MU2, there remains the risk of a large wave event occurring that could cause significant crest lowering resulting in overtopping, overwashing or even breaching of Chesil Beach, particularly in the north-western part of the BMP area in MU3. Should such an event occur, then rapid inundation could occur, flooding Chiswell and affecting road access via the A354 Portland Beach Road.

In terms of beach management activity in response to such an event, use of excavators, dump trucks and bulldozers is likely to be required to move material that has been pushed over the beach crest (and deposited as overwash deposits) back up the beach backslope in order to restore the defence function of the beach. This activity will seek to restore the 'typical' pre-event barrier beach profile. It would be likely that the profile would be restored in a more landwards position in MU3, reflecting the fact that a large amount of material is likely to have moved eastwards during such an event and it will be easier to rebuild the profile where the bulk of the material resides rather than moving it all back seawards. However, the practicality of this will depend upon the extent of impact on property and infrastructure and a decision will need to be made by those on site post-event about exactly where material needs to be placed to restore the profile. Indeed, a breach within the gabion mattresses (MU2) or the south-eastern end of MU3 would need to be repaired in an appropriate alignment with the existing defences in order to maintain the future integrity of the coastal defence scheme. However, if the result of a large event does not pose a risk to infrastructure or property, it may be more practical to not intervene at all but simply allow the beach to recover naturally in a more eastwards position. This approach may be most appropriate towards the north-western end of MU3 where the beach is backed by the Fleet. In this instance, advice should be sought from Natural England and other relevant parties.

As part of restoring the beach profile following a large event, it may be necessary to remove shingle from the culverts and flood alleviation channel. The procedures for doing this as set out in **Section 5.1.1** should also be followed in these circumstances.

These Crisis Level works should also be undertaken alongside the procedures set out in the emergency plan for Chiswell (refer to **Section 1.7.12**).

5.4 Implementation Requirements

5.4.1 Beach Recycling and Re-profiling

Beach recycling and re-profiling will typically be carried out using a tracked bulldozer and a hydraulic excavator, although other plant may be used as appropriate such as dump trucks. In order to reduce the impact of plant on the beach sediment (i.e. minimise compaction and/or disturbance of beach sediment), **it is recommended that routes used by plant are continually altered (refer also to Section 5.4.4).**

Beach recycling and re-profiling will aim to retain the beach crest adjacent to the seawalls in MU1 within an envelope of levels between the upper and lower Action Levels (i.e. the beach crest should no more than 1.5m from the wall crest and more than 1m above the toe level of the seawalls – refer to **Section 3.3**).

In MU2, the aim will be to retain at least 300mm of shingle over the gabion mattresses and ensure that the beach level is at least 1m above the toe level of the gabion castle and mattresses (refer to **Section 3.3**).

In MU3, routine (infrequent) works are only to be undertaken to clear shingle from the flood alleviation channel and/or culverts.

In addition, works may be required following a large wave event if needed to restore the defence function of the beach, or recycling and re-profiling of this area will restore as far as possible the 'pre-event' barrier beach profile and only occur for a short period following the event, whereafter the beach will again be allowed to evolve naturally, in line with the SMP policy for this section (refer to **Section 1.7.1**).

5.4.2 Structure Maintenance and Repairs

Maintenance and repairs to hard-coastal defence assets along the BMP area will typically be carried out by tracked plant and/or other specialized plant (e.g. piling rigs), depending upon the exact nature of the works. As with beach recycling and re-profiling works described in **Section 5.4.1**, when works occur to these hard-defence assets that require plant to be on the beach, in order to reduce the impact of plant on the beach sediment (i.e. minimise compaction and crushing of beach sediment), it is recommended that routes used by plant are continually altered (refer also to **Section 5.4.4**).

5.4.3 Plant Requirements

As discussed in **Sections 5.4.1 and 5.4.2**, hydraulic (swing shovel) excavators along with tracked bulldozers, dump trucks and other specialized plant are to be used to undertake works along the BMP area. Rubber tracked plant are not available in the plant size required for viable works along the BMP area, therefore regular tracked plant, suitably sized for the work, will be appropriate when undertaking works. This will typically be excavators (or similar) and D8 bulldozers (or similar) up to 40T (this being the weight limit allowed for crossing the culvert).

This land-based plant could be required at any time of the year, such is the nature of the risk posed by swell wave events in particular. As such, plant should be readily available for rapid deployment to re-profile the beach following large wave events as required.

In addition, should it be necessary for the Environment Agency Operations Delivery Team to be supported by the military and/or contractors (employed via the Environment Agency's supplier framework) in future recovery works (as occurred in response to the winter 2013/14 storms), then suitably sized plant (within the limits stated above) and competent operators would be required, using the same site access requirements described above.

5.4.4 Access for Works

Plant access to the beach in MU1 and MU2 will continue to be via the Masonic Car Park (refer to **Figure 5.2**). To support this, a compound is to be used in the Masonic Car Park. **Figure 5.3** shows proposed compound extents and preferred access routes over the beach (taking account of utilities beneath the beach – refer to **Section 5.1.1**), but **the final compound extent and access routes should be agreed between the Environment Agency, Natural England and the Jurassic Coast's Earth Science Manager (refer to Appendix G.2) in the immediate future** such that all parties know where it is before it needs to be used. In seeking this agreement, and with regards to **Figure 5.3**, the following is to be noted:

- The compound should be located at Site 1 (refer to **Figure 5.3**) in the Masonic car park if the gabions are intact and allow access over them; otherwise access to the beach would be via an alternative site by the windows (Site 2 on **Figure 5.3**). If access is over the front

face of the gabion mattresses in MU2, then the angle of the slope should be sufficiently shallow as to allow safe passage. Should Site 2 be used at first, once access allows, the site compound could be relocated back from Site 2 to Site 1 in the main car park for the duration of any remaining works.

- When accessing over the beach with plant, the route used should be regularly altered to prevent compaction and/or disturbance of material along a single track route (refer also to other plant requirements in **Sections 5.4.1 to 5.4.3**). The exception to this is the initial access route onto and over the beach crest, as this must be carefully constructed and maintained throughout the works. Spragging by plant on the shingle (i.e. turning 'on the spot') is also to be kept to a minimum.
- Should it be necessary for the Environment Agency Operations Delivery Team to be supported by the military in future recovery works (as occurred in response to the winter 2013/14 storms), then the same compound and access arrangements will apply.

This location in the Masonic Car Park may also be utilised, if practical, following large wave events to restore the defence function of the beach in MU3 in line with the SMP policy (**Section 1.7.1**); particularly in the area near to the Masonic Car Park. However, it may be more practical to access parts of MU3 via either the lay-by adjacent the Portland Harbour Culvert at the north-west end of the flood alleviation channel, or the Chesil Beach Visitor Centre car park (refer to **Figure 5.2**). If access is from the visitor centre car park, then an additional issue will be the reduced ease of access to the beach from the car park, which is restricted by the tide in parts. An alternative would be to access the beach at the south-eastern end of the visitor centre car park where tidal restriction is not an issue. However, features of designation in regards to the SAC (vegetated stony bank) are located in this area and so access from this area needs to minimise impacts on this. **Should a situation arise that requires use of either of these two locations in MU3, it is recommended that the Environment Agency (or others) use the recommended access route from the relevant area onto the beach shown in Figure 5.4. Routes along the beach will depend on the location of any issues to be addressed and will need to be continually altered to reduce impact of plant on the beach sediment. The extent of any compound that may be required within the visitor centre car park will need to be agreed at the time with Natural England and other stakeholders, as would any additional/alternative access route that may be needed from the lay-by adjacent the Portland Harbour Culvert at the north-west end of the flood alleviation channel.** This will ensure that impacts on vegetation by plant movement, should any be present following a large wave event, be minimised.

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Figure 5.2 Beach access points.

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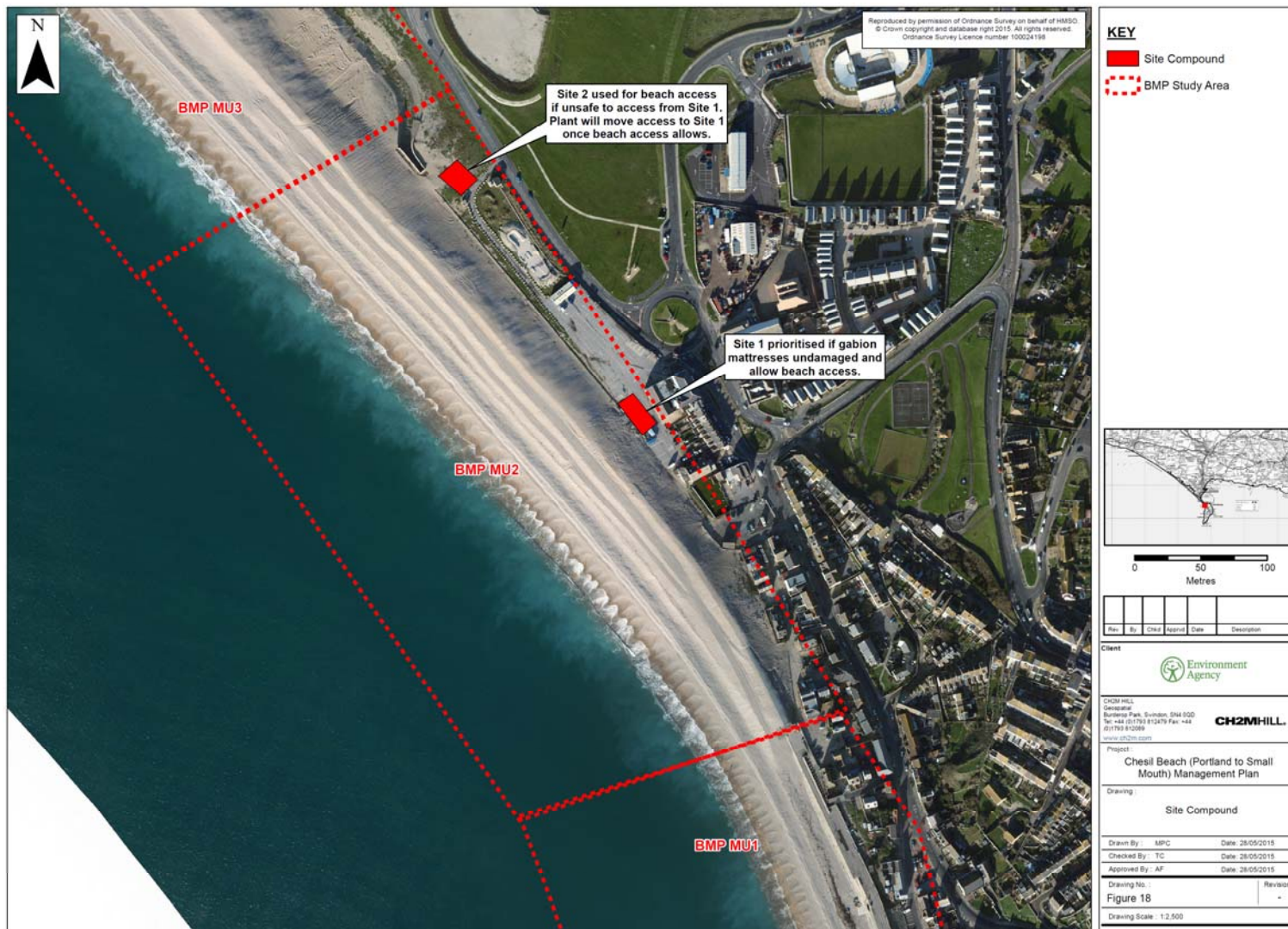


Figure 5.3 Proposed compound extents in the Masonic Car Park and access routes over the beach.

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Figure 5.4 Recommended route onto the beach in MU3 from the visitor centre car park.

5.4.5 Public Access, Amenity and Safety

Beach management activities should avoid the peak holiday season, weekends and public holidays where possible. This will minimise the impact of works on beach users and will reduce the minor risk to public safety that such work would pose. In order to ensure the safety of the public whilst works are being carried out, restrictions on public access to the areas of the beach being worked on should be implemented, with alternative routes provided if possible.

A key lesson from post-storm recovery works in 2014 was that the public will still want to access the site even when works are occurring along the beach (to view the works and/or storm damage), and as such closing the beach entirely when works are undertaken is likely to be impractical. Therefore **it is recommended that a banksman is present with each machine, and that either spare personnel or a dedicated communications officer, along with signage, are employed to direct public access to safe sections of the promenade and beach during works.**

Information boards should be displayed whilst the works are being carried out to explain what is being done and why. This will also serve to improve public education. **Appendix O** contains a best practice guide on how to communicate with the public and local businesses when undertaking beach maintenance works.

5.4.6 Notifying Others

In addition to communicating effectively with the public (refer to **Section 5.4.5**), **it is recommended that explicit notification of any works, and contact details should there be any queries, be provided to the following organisations/groups as appropriate depending upon the location where works are occurring:**

- Natural England (in relation to nature conservation and coastal access interests);
- World Heritage Site (in relation to nature conservation interests);
- Dorset Historic Environment Officer (in relation to historic environment interests); and
- Weymouth & Portland Borough Council (in relation to coast protection interests).
- Portland Town Council;
- The Marine Management Organisation;
- The Crown Estate;
- Local fishermen/anglers and those people who have a day to day interest in what is happening along the frontage where works are to occur, i.e. any businesses that may be affected;
- Local residents directly affected by any road or access closures along the frontage when works occur.

Contact details for a number of these are contained in **Appendix G.2**.

6 ACTION PLAN

This section provides a summary of the recommendations made throughout the rest of this BMP in the form of an action plan. The action plan is presented in **Table 6.1** and identifies actions by type as being either for 'Management', 'Monitoring', 'Maintenance', 'Emergency Planning' or 'For Future Studies/Research'.

It is intended that this Action Plan be used to guide future investment in this area which will ultimately enable more appropriate, effective and efficient maintenance practices to be established and implemented along the BMP area, and in particular in MU1 and MU2.

Table 6.1 Chesil Beach (Portland to Small Mouth) Management Plan: Action Plan

Action No.	Action Description	Who by?	Date action First Defined?	When by?	Related BMP Section	Current Status
MANAGEMENT ACTIONS						
MAN_001	Undertake a review of this BMP after 5 years.	Environment Agency	April 2015	June 2020	Section 1.2	Not started
MAN_002	A Habitats Regulations Assessment should be completed alongside any future update of this BMP, in line with the requirements of the Conservation of Habitats and Species Regulations (2010) or any superseding requirements in place at the time, to ensure that the updated management regime identified in any future BMP does not cause significant adverse effects for the features of interest of the site.	Environment Agency	April 2015	June 2020	Section 1.4.2	Not started
MAN_003	Discussions should be held with the relevant consenting organisations in a timely manner to ensure that all requirements of licence/consent applications are confirmed and either addressed in order to minimise the risk of delays in being able to implement works, or letters of comfort stating explicitly the activities that do not require specific consent. Where necessary, these discussions should also assess the applicability of progressing any required licence application through the streamlined process defined in the Coastal Concordant for England published in November 2013 (Defra, 2013).	Environment Agency	April 2015	March 2016	Section 1.6	Not started
MAN_004	Ownership of all assets such as walls at the back of the beach in MU2 is uncertain and so the ownership of these walls should be confirmed in the immediate future such that future maintenance requirements can be planned.	Environment Agency / WPBC	April 2015	March 2016	Section 4.2.1	Not started
MONITORING ACTIONS						
MON_001	Continue the ongoing monitoring that forms part of the South West Regional Coastal Monitoring Programme.	Plymouth Coastal Observatory / Environment Agency	November 2010; re-confirmed April 2015	Ongoing	Section 4	Ongoing
MON_002	Seek to implement additional monitoring recommendations identified in the BMP in order to inform the future revision of the BMP in 5 years' time. This should include:	-	-	-	-	-
	a) Mark that at least some of the last 3 digits of the beach profile ID numbers along the sea wall at the back of Chesil Beach in MU1.	Environment Agency	November 2010; re-confirmed April 2015	June 2015	Section 4.1.1	Completed
	b) To aid efforts to improve coastal processes understanding (refer to Section 1.4.4), it is recommended that regular monitoring of beach profiles, as well as aerial photography and LiDAR surveys, be extended further to the north-west of the BMP extent as far as Abbotsbury.	Environment Agency	April 2015	Ongoing	Section 4.1.1 and Section 4.1.8	Ongoing
	c) The monitoring and routine reporting on additional beach parameters, such as beach plan shape, crest level and crest width above given threshold level should occur.	Environment Agency	November 2010; re-confirmed April 2015	After each survey and/or annually	Section 4.1.1 and Section 4.6	Ongoing
	d) The current extent of beach profile surveys that are routinely monitored do not cover the most south-eastern part of the BMP area. Additional beach profiles should be surveyed in the most south-eastern part of MU1 (fronting the south-easternmost part of the WPBC wall), and on a more frequent basis than Spring and Autumn for a period of at least 2 years.	Environment Agency	November 2010	Ongoing	N/A (See section 4.2.1 of BMP v1.0 from November 2010)	Completed

Action No.	Action Description	Who by?	Date action First Defined?	When by?	Related BMP Section	Current Status
	e) Occasional surveys of the flood alleviation channel should be undertaken to monitor the channel profile in relation to the design profile.	Environment Agency	November 2010; re-confirmed April 2015	Annually (each Spring)	Section 4.1.1	Ongoing
	f) Changes to the way in which post-storm surveys are triggered should be explored and mechanisms put in place. As an interim measure, until more data is available to refine understanding, it is recommended that pre-/post-storm beach profile surveys be triggered by the Environment Agency when an event occurs (or is forecast to occur) whereby the following levels will be met/exceeded: <ul style="list-style-type: none"> Wave period = 12s or greater. Significant wave height = 5m or greater. Tide levels at Weymouth = 1.8mOD or greater. 	Environment Agency	November 2010; re-confirmed April 2015	Ongoing	Section 4.1.1	Ongoing
	g) Consideration to triggering pre-storm surveys could also usefully be undertaken if a forecast storm event is thought likely to result significant impacts on the beach morphology (refer also to Action 'MON_002(f)').	Environment Agency	November 2010; re-confirmed April 2015	As required	Section 4.1.1	Ongoing
	h) Multi-beam bathymetry surveys should be undertaken following any future storm event that causes changes to Chesil Beach in a similar way to that experienced as a result of the winter 2013/14 storms (refer to <i>Section 1.3.1</i> and Section 7.4 of Appendix E). In such situations, multi-beam bathymetry survey should be undertaken as soon as possible after the event to capture nearshore changes to the seabed levels and sediment composition.	Environment Agency	April 2015	As required, after storms	Section 4.1.4	Ongoing
	i) Details of the storm conditions (waves, winds and water levels) will need to be recorded in support of the post-storm profile surveys (refer also to Action 'FUT_009'). Details of the impacts of storm events will also need to be recorded in terms of where and when flooding occurred and to what extent and what was impacts (e.g. properties flooded; roads closed etc). This information should be captured through date/time stamped photographs, videos, flood reconnaissance reports, and media (including social media) reporting.	Environment Agency	November 2010; re-confirmed April 2015	As required	Section 4.4.2	Ongoing
MON_003	Visual walkover inspections should continue to be undertaken by the Environment Agency to monitor beach crest level against the seawall, as well as depth of shingle over the gabions and infilling of the flood alleviation channel by shingle pushed in by the formation of 'canns'.	Environment Agency	November 2010; revised April 2015	Annually, plus after storms	Section 4.1.6	Ongoing
MON_004	An annual visual inspection of all of the coastal defence structures along the BMP frontage should be undertaken.	Environment Agency; WPBC	November 2010; revised April 2015	Annually, plus after storms	Section 4.2.1	Ongoing
MON_005	Full structural inspections of the seawalls, gabion castle and mattresses, slope stabilisation measures, interceptor drain, flood gates and culverts along MU1, MU2 and MU3 should be carried out every five years.	Environment Agency; WPBC	November 2010; revised April 2015	2015	Section 4.2.2	Ongoing
MON_006	Monitoring of the gabions for the issues identified in this BMP should be further considered as part of the EA study into the future of the gabions that is to occur in 2010/11.	Environment Agency	November 2010	2011	N/A (See Section 4.3.1 of BMP v1.0 from November 2010)	Completed

Action No.	Action Description	Who by?	Date action First Defined?	When by?	Related BMP Section	Current Status
MON_007	Monitoring of the many environmental features within the BMP area (both natural and historic) should be carried out to enable evaluation of any long-term effects that may (or may not) be caused by the beach management regime set out in this BMP, including assessment of the impacts of any works that occur.	Environment Agency; Natural England; Fleet Study Group <i>(to be confirmed)</i>	November 2010; re-confirmed April 2015	Ongoing	Section 4.3	Ongoing
MAINTENANCE ACTIONS						
MAI_001	<p>Trigger levels defined in the BMP should be used to guide when beach maintenance works are required.</p> <p>However, the application of trigger level values should not be absolute, and consideration should also be given to sea conditions at the time of the assessment. It is therefore recommended that unless further severe weather is expected, several days (4-5 days) should be allowed for the beach to recover following the storm before remedial actions to recover beach levels are implemented, unless there is the likelihood of catastrophic failure of the hard-defences if such a delay were taken.</p> <p>In taking this approach of waiting several days, it is important to recognise that it is likely that only recovery of the lower part of the beach will be observed (if any) in this short time-frame; the upper part of the beach is likely to remain at reduced levels for a considerable period of time following the storm event. This is based upon experience following the winter 2013/14 storms.</p>	Environment Agency	November 2010; re-confirmed April 2015	Ongoing	Section 3.3	Ongoing
MAI_002	<p>When either routine inspection or rapid assessment following a storm event identifies a defect in the defence, be it a crack in the defence or damage to public safety aspects of the defence (e.g. buckled hand railings or trip hazards etc.) then the following steps are to be followed:</p> <ol style="list-style-type: none"> Increased defect monitoring – should any defects be identified then it may be appropriate to implement an increased level monitoring rather than immediately undertaking remedial works. This could also involve the use of additional monitoring devices such as crack gauges. This step would only occur if the identified defect is not considered an immediate safety risk (i.e. this step is optional and may or may not occur prior to Step 2). Remedial works – once an identified defect is considered to be in need of remedial work, then the design of remedial works should be undertaken and an appropriate repair specification generated. To ensure consistent information on repairs undertaken is recorded, a defence repair record template is provided in Appendix N. 	Environment Agency; WPBC	April 2015	As required	Section 5.1.2	Ongoing
MAI_003	Implement the recommendations identified in the BMP when undertaking works on the beach. This should include:	-	-	-	-	-
	a) New services and utilities checks should be carried out before any works occur on site.	Environment Agency	November 2010; re-confirmed April 2015	As required	Section 1.3.7	Ongoing
	b) Consent is needed from Natural England each time works are carried out in the SSSI area (refer also to Action 'MAN_003').	Environment Agency	November 2010; re-confirmed April 2015	As required	Section 1.6.1	Ongoing
	c) Beach recycling logs are to be maintained whenever beach maintenance works occur. It is recommended that two separate beach surveys, 'in' (pre-recycling) and 'out' (post-recycling), are undertaken for the first few beach recycling campaigns to validate the logs.	Environment Agency	November 2010; re-confirmed April 2015	As required	Section 4.1.3	Ongoing

Action No.	Action Description	Who by?	Date action First Defined?	When by?	Related BMP Section	Current Status
	d) It is recommended that a banksman is present with each machine, and that either spare personnel or a dedicated communications officer, along with signage, are employed to direct public access to safe sections of the promenade and beach during works	Environment Agency	November 2010; revised April 2015	Ongoing	Section 5.4.5	Ongoing
	e) Information boards should be displayed whilst the works are being carried out to explain what is being done and why.	Environment Agency	November 2010; re-confirmed April 2015	Ongoing	Section 5.4.5	Ongoing
	f) The EA should continue to work with WPBC to ensure that the management of the beach is complimentary of the management of the coast protection seawall.	Environment Agency	November 2010; re-confirmed April 2015	As required	Section 5.2.1	Ongoing
	g) In order to reduce the impact of plant on the beach sediment (i.e. minimise compaction and crushing of beach sediment), it is recommended that routes used by plant are continually altered.	Environment Agency	April 2015	As required	Section 5.4.1	Ongoing
	h) The Masonic Car Park is to act as the primary compound area and access route for works on the beach face in MU1 and MU2. The final compound extent and access routes should be agreed between the Environment Agency, Weymouth & Portland Borough Council, Natural England and the Jurassic Coast's Earth Science Manager in the immediate future.	Environment Agency	April 2015	March 2016	Section 5.4.4	Not started
	i) Should a situation arise that requires access to MU3 to undertake beach management works, it is recommended that the Environment Agency (or others) use the recommended access route from the relevant area onto the beach shown in <i>Figure 5.4</i> . Routes along the beach will depend on the location of any issues to be addressed and will need to be continually altered to reduce impact of plant on the beach sediment. The extent of any compound that may be required within the visitor centre car park will need to be agreed at the time with Natural England and other stakeholders, as would any additional/alternative access route that may be needed from the lay-by adjacent the Portland Harbour Culvert at the north-west end of the flood alleviation channel (see also Action 'MAI_003(h)').	Environment Agency	April 2015	As required	Section 5.4.4	Ongoing
	j) Notification of beach works should be explicitly given to key organisation and other stakeholders with interests in the area.	Environment Agency	November 2010; revised April 2015	As required	Section 5.4.6	Ongoing
EMERGENCY PLANNING						
EMP_001	The current emergency plan is the <i>Chiswell Operational Response Plan</i> . This is published and kept under review by emergency planning teams in Dorset County Council and Weymouth & Portland Borough Council. The Environment Agency should continue to work with these organisations to develop future revisions of this emergency plan to ensure that the risks identified in this BMP are addressed in the plan. This could include consideration of evacuation routes for residents and restoration of the beach defence function and transport links (should the A354 be affected) (refer also to Action FUT_007).	Environment Agency / Dorset County Council / Weymouth & Portland BC	April 2015	Ongoing	Section 1.7.10	Ongoing
EMP_002	There is a need to ensure public awareness and education of the flood risks is maintained and this should form a key part of the ongoing strategy in this area.	Environment Agency	November 2010; re-confirmed April 2015	Ongoing	Section 1.4.1.2	Ongoing
FOR FUTURE STUDIES/RESEARCH						
FUT_001	Ongoing research into the use of CCTV should engage all EA operators with interests in Chiswell to ensure that benefits from the CCTV camera are recognised in as many areas as possible.	Environment Agency / University of Plymouth	November 2010	Ongoing	N/A (See Section 4.2.7 of BMP v1.0 from November 2010)	Completed

Action No.	Action Description	Who by?	Date action First Defined?	When by?	Related BMP Section	Current Status
FUT_002	A CCTV survey of the drain under Victoria Square should be undertaken as planned in Autumn 2010 and the results appended to this BMP in Appendix K.	Environment Agency	November 2010	January 2011	N/A (See Section 3.1 of BMP v1.0 from November 2010)	Completed
FUT_003	Opportunities should be sought to undertake research in the following additional areas to aid future management of this area, including:	-	-	-	-	-
	a) Definition of the definitive master profile;	Environment Agency / Universities	November 2010; re-confirmed April 2015	If/when opportunity arises	Section 4.1.2	Not started
	b) Improve understanding of sediment composition and porosity both along and within the beach; and	Environment Agency / Universities	November 2010; re-confirmed April 2015	If/when opportunity arises	Section 4.1.5	Not started
	c) Examining the relationship between beach water levels, beach sediment composition, wave (both locally generated and swell) and wind climate and tide conditions.	Environment Agency / Universities	November 2010; re-confirmed April 2015	If/when opportunity arises	Section 4.1.9	Not started
FUT_004	Consider undertaking an updated assessment of the economic case for continued FCERM activities to derive updated estimate of benefits (reflecting recent developments and price changes) as well as actual costs spent to date maintaining the defences and a projection of future maintenance costs. A calculation of partnership funding levels should also be undertaken to determine if efforts are needed to seek additional funding sources in the future.	Environment Agency	April 2015	If/when opportunity arises	Section 1.1	Not started
FUT_005	Undertake a full review (and possible rationalisation) of all Chiswell flood modelling and mapping completed to date should be undertaken to ensure that the uncertainties and limitations of each modelling study are well understood in order that the Environment Agency can ensure that the 'best available' information is used for flood risk mapping and warning at Chiswell in the future, as well as informing any updated economic assessment. This review should also consider (a) how well (or not) the flood modelling work that has been undertaken assesses the relationship between flow rates/water levels passing through 'The Windows' into the Monsoon Channel and corresponding flood risk to guide revisions of flood warning criteria based on 'The Windows' telemetry data; and (b) potential limitations of previous flood modelling work where no allowance has been made for highway drainage infrastructure beneath the A354 Portland Beach Road (refer also to Action FUT_004).	Environment Agency	April 2015	March 2017	Section 1.1	Not started
FUT_006	Consideration should be given to alternative ways of determining how the overall defence system performs during extreme events and thus how the SoP is defined, as simply assessing SoP against wave overtopping is not an accurate reflection of how the overall flood risk to people and property is dealt with by the defence system that is designed to minimise and accommodate coastal flooding rather than prevent it.	Environment Agency / Universities	April 2015	If/when opportunity arises	Section 1.4.1.1	Not started
FUT_007	It is vital that emergency plans (refer to Section 1.7.9) are robust and set out measures to be taken should a large event occur to the extent that has occurred in the past. To date, only analysis of monitoring data and associated impacts relating to the winter 2013/14 storms has been undertaken (CH2M HILL, 2014a) and further investigation in this area should be considered.	Environment Agency / Universities	April 2015	If/when opportunity arises	Section 1.4.1.2	Not started
FUT_008	It is recommended that a more detailed review and update of the coastal processes understanding presented in Appendix E be undertaken. This should draw upon the monitoring data collected since 2007 and in particular, the data collected during and since the winter 2013/14 storms to assess, amongst other things:	Environment Agency	April 2015	March 2016	Section 1.4.4	Not started

Action No.	Action Description	Who by?	Date action First Defined?	When by?	Related BMP Section	Current Status
	<ul style="list-style-type: none"> The extent of draw-down of the beach against the seawall and recovery of beach levels during and immediately following storm events, using data from University of Plymouth for the 5th February 2014 storm; and The impact and effectiveness of beach recycling activities in beach recovery operations following the winter 2013/14 storms (refer to Section 1.4.1.2), utilising both beach profile survey data, LiDAR data and bathymetry survey data collected by the Environment Agency and PCO. The wave and water level climate experienced during the winter 2013/14 storms, including the bi-modal nature of the events (refer to Section 2.1.2) and the extreme joint probability of the events (refer to Section 2.3). <p>This updated analysis could also usefully:</p> <ul style="list-style-type: none"> Include analysis of data to the north-west of the BMP study extent (i.e. at least towards the Bridging Camp and possibly beyond) to assess changes in Chesil Beach in that area and investigate if any sediment moved from the BMP area to here during the winter 2013/14 storm events. This could be achieved using LiDAR data to assess profile changes along positions defined by Duane and Bray (2005), alongside any other available survey data that may have been captured in this area by others (e.g. The Fleet Study Group); and Reflect any findings from recent R&D work such as that by University of Plymouth, ongoing R&D such as that by SCOPAC and HR Wallingford, and any future planned R&D to address any of the uncertainties (refer to Appendix F). 					
FUT_009	In order to improve the recording of tide level data at this south-eastern end of Chesil Beach, it is recommended that a hydrodynamic modelling study be carried out to enable parameters to be established for converting recorded levels at West Bay and/or Weymouth Harbour to be related more equivocally to the BMP area. This could form part of work recommended in Action FUT_008.	Environment Agency	April 2015	If/when opportunity arises	Section 4.4.1	Not started

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GLOSSARY

Term	Definition
Action Level	One of two trigger levels, this is the trigger level below Crisis Level. This is usually a predetermined value where the monitored beach parameter falls to within range of the Action Level, but has not resulted in systematic failure of the function being monitored, e.g. recession of a beach crest eroding to within 10m of an asset, where it has been predetermined that an extreme storm event could result in recession of 5m. The Action Level in this example is therefore a 5m buffer. Increased monitoring would be required when an Action Level is compromised and intervention undertaken if deemed necessary. Managing Action Levels can be planned in advance.
Accretion	Accumulation of sediment due to the natural action of waves, currents and wind.
AONB	Area of Outstanding Natural Beauty. Designated by the former Countryside Agency (now Natural England). The purpose of the AONB designation is to identify areas of national importance and to promote the conservation and enhancement of natural beauty. This includes protecting its flora, fauna, geological and landscape features. This is a statutory designation.
APO	Annual probability of occurrence.
Appropriate Assessment (AA)	Appropriate Assessment: Regulation 48 of the Habitats Directive (92/43/EEC) requires that an Appropriate Assessment is undertaken for plans or projects that may have a likely significant effect on a European site (e.g. sites designated as SPA or SAC), where the plan is not directly associated with the management of the site. The purpose of AA is to determine whether the plan or project will have an adverse effect on the integrity of the site, either alone or in combination with other plans, programmes and projects.
ATT	Admiralty Tide Table.
Backwash	The seaward return of the water following the up-rush (swash) of the waves. For any given tide stage the point of farthest return seaward of the backwash is known as the Limit of backwash.
BAP	Biodiversity Action Plan. A strategy for conserving and enhancing wild species and wildlife habitats in the UK.
Beach	A deposit of non-cohesive material (e.g. sand, gravel) situated on the interface between dry land and the sea (or other large expanse of water) and actively 'worked' by present day hydrodynamic processes (i.e. waves, tides and currents) and sometimes by winds.
Beach Plan Shape	The shape of the beach in plan; usually shown as a contour line, combination of contour lines or recognizable features such as beach crest and/or the still water line
Beach Profile	Cross-section perpendicular to the shoreline. The profile can extend seawards from any selected point on the landward side or top of the beach into the nearshore.
Beach recharge (nourishment)	Artificial process of replenishing a beach with material from another source.

Term	Definition
Beach recycling/re-profiling	The movement of sediment along a beach area, typically from areas of accretion to areas of erosion, and shaping the beach profile to have a desired crest height, width and slope.
Berm	A ridge located to the rear of a beach, just above mean high water. It is marked by a break of slope at the seaward edge.
Bimodal wave period	Related to frequency distribution of waves, for each bimodal wave periods two wave peaks are observed.
BMP	Beach Management Plan. It provides a basis for the management of a beach for coastal defence purposes, taking into account coastal processes and the other uses of the beach.
Breaching	Failure of the beach head allowing flooding by tidal action.
Cefas	Centre for Environment, Fisheries and Aquaculture Science. An executive agency of the United Kingdom government Department for Environment, Food and Rural Affairs (Defra).
CIRIA	Construction Industry Research and Information Association.
Climate Change	Long term changes in climate. The term is generally used for changes resulting from human intervention in atmospheric processes through, for example, the release of greenhouse gases to the atmosphere from burning fossil fuels, the results of which may lead to increased rainfall and sea level rise.
Coastal squeeze	The reduction in habitat area which can arise if the natural landward migration of a habitat under sea level rise is prevented by a fixation of the high water mark.
Crest	Highest point on a beach face, breakwater or seawall.
Crest level/height	The vertical level of the beach relative to mOD.
Crest width	The horizontal distance of the beach measured from the seaward edge of the promenade to the point where the beach slope angle drops down towards the sea.
Crisis Level	One of two trigger levels, this is the trigger level at which the function being monitored, such as the stability of the beach and/or any backing structures (seawall/promenade), could be compromised and emergency remedial action becomes necessary, e.g. as in the case described under Action Level above, the beach crest recedes to within 4m of an asset that requires protection, where it has been predetermined that an extreme event could result in 5m of recession.
DCC	Dorset County Council. Has a variety of roles including emergency planning, Lead Local Flood Authority and highways authority. Also host the UNESCO World Heritage Site management team.
Defra	Department for Environment, Food and Rural Affairs (formerly known as MAFF)
Depth of Closure	The 'seaward limit of significant depth change' it does not refer to an absolute boundary across which there is no cross-shore sediment transport.
Doorstep Green	A permanent area of public green space close to people's homes in disadvantaged areas where regeneration of the local environment is crucial. Doorstep Greens were established between 2001 and 2003 with advice from

Term	Definition
	the Countryside Agency (now Natural England) and funding from The Big Lottery Fund. Each Doorstep Green is now managed by a charitable trust who fundraise for and maintain each space in perpetuity.
Drift-aligned	A coastline that is orientated obliquely to prevailing incident wave fronts.
Drift reversal	A switch of an indigenous direction of littoral transport.
EA	Environment Agency. UK non-departmental government body responsible for delivering integrated environmental management including flood defence, water resources, water quality and pollution control.
Erosion	Wearing away of the land, usually by the action of natural forces.
Fetch length	The distance that the wind has passed across the water in one direction (the greater the fetch, the larger the wind-driven waves will be).
Flood and Coastal Risk Management	Flood and coastal risk management addresses the scientific and engineering issues of rainfall, runoff, rivers and flood inundation, and coastal erosion, as well as the human and socio-economic issues of planning, development and management.
Flood Zone	A geographical area officially designated subject to potential flood damage. The Environment Agency uses Flood Zone 2 and Flood Zone 3.
Gabion	Steel wire-mesh basket to hold stones or crushed rock held tightly together usually to form blocks or walls.
Geomorphology/morphology	The branch of physical geography/geology which deals with the form of the Earth, the general configuration of its surface, the distribution of the land, water, etc.
Hard defence	General term applied to impermeable coastal defence structures of concrete, timber, steel, masonry etc, which reflect a high proportion of incident wave energy.
Heritage Coast	A Heritage Coast is a strip of UK coastline defined by Natural England as having notable natural beauty or scientific significance.
Hold the Line	An SMP policy to maintain or change the level of protection provided by defences in their present location.
IPCC	Inter-Governmental Panel on Climate Change.
Joint probability	The probability of two (or more) things occurring together.
Joint Probability Analysis (JPA)	Function specifying the joint distribution of two (or more) variables.
Joint return period	Average period of time between occurrences of a given joint probability event.
LGAP	Local Geodiversity Action Plan.
LiDAR	Light Detection and Ranging. This is an airborne mapping technique which uses a laser to measure the distance between the aircraft and the ground.
Listed Building	A building or other structure officially designated as being of special architectural, historical or cultural significance.
LNR	Local Nature Reserve. These are established by local authorities in consultation with Natural England. These sites are generally of local significance and also provide important opportunities for public enjoyment, recreation and interpretation. This is a non-statutory designation.

Term	Definition
Locally generated (wind) waves	Locally generated short period and irregular waves created by the flow of air over water.
Longshore transport	Movement of material parallel to the shore, also referred to as longshore drift.
mCD	metres Chart Datum. Approximately the lowest astronomical tidal level, excluding the influence of the weather.
MMO	Marine Management Organisation. An executive non-departmental public body established and given powers under the Marine and Coastal Access Act 2009. Responsible for managing activities in the marine environment including marine licensing and marine planning.
mOD	metres Ordnance Datum. A universal zero point used in the UK, equal to the mean sea level at Newlyn in Cornwall.
MoD	Ministry of Defence.
Managed Realignment	An SMP policy allowing the shoreline to move backwards or forwards, with management to control or limit movement. This includes reducing erosion or building new defences on the landward side of the original defences.
Management Unit (MU)	The BMP frontage is split into 3 Management Units (MU's) within which slightly different management approaches are required.
MCZ	Marine Conservation Zone designated under the provisions of the Marine and Coastal Access Act 2009.
Met Office	UK Meteorological Office.
Natural England	A non-departmental public body of the UK government responsible for ensuring that England's natural environment, including its land, flora and fauna, freshwater and marine environments, geology and soils, are protected and improved. It also has a responsibility to help people enjoy, understand and access the natural environment.
NCA	National Character Area.
No Active Intervention	An SMP policy that assumes that existing defences are no longer maintained and will fail over time or undefended frontages will be allowed to evolve naturally.
Non-designated archaeological sites	Historical and archaeological structures, features and finds, as well as buildings and landscapes of historical or architectural interest within a given county or unitary authority area that are contained in the Historic Environment Record (formerly Sites and Monuments Register (SMR)) but which are not cited under statutory designations such as Listed Building or Scheduled Monument.
Overtopping	Water carried over the top of a coastal defence due to wave run-up exceeding the crest height.
Overwashing	The effect of waves overtopping a coastal defence, often carrying sediment landwards which is then lost to the beach system.
PCO	Plymouth Coastal Observatory. Based at University of Plymouth, responsible for the South West Regional Coastal Monitoring Programme (SWRCMP).
Percolation	The process by which water flows through the interstices of a sediment. Specifically, in wave phenomena, the process by which wave action forces water through the interstices of the bottom sediment and which tends to reduce wave heights.

Term	Definition
Policy Unit	A Policy Unit relates to the policy area defined by the Shoreline Management Plan (SMP).
Ramsar	Designated under the, "Ramsar Convention on Wetlands of International Importance especially as Waterfowl Habitat." 1971. The objective of this designation it to stem the progressive encroachment onto, and loss of wetlands.
Registered Park and Garden	Parks and gardens registered for their historic value so they are considered in the planning process. Local planning authorities must consult English Heritage where planning applications may affect these sites.
Relict	Features or sediment formed or deposited by processes no longer active in the area.
Return Period	A statistical measurement denoting the average probability of occurrence of a given event over time.
RIGS	Regionally Important Geological/Geomorphological Sites. A non-statutory designation identified by locally developed criteria and are currently the most important places for geology and geomorphology outside statutorily protected land such as SSSI's.
SAC	Special Area of Conservation. This designation aims to protect habitats or species of European importance and can include Marine Areas. SACs are designated under the EC Habitats Directive (92/43/EEC) for plant and animal species (not birds which are covered by SPA) and will form part of the Natura 2000 site network. All SACs sites are also protected as SSSI, except those in the marine environment below the Mean Low Water (MLW). The exception to this is the Fleet lagoon, which is also designated as a SSSI below MLW.
Scheduled Monument	Scheduled Monument: formerly referred to as Scheduled Ancient Monuments. Scheduled Monuments are nationally important archaeological sites which have been awarded scheduled status in order to protect and preserve the site for the educational and cultural benefit of future generations. The main legislation concerning archaeology in the UK is the Ancient Monuments and Archaeological Areas Act 1979. This Act, building on legislation dating back to 1882, provides for nationally important archaeological sites to be statutorily protected as Scheduled Monuments.
SCOPAC	Standing Conference On Problems Associated with the Coastline. A group of local authorities and other organisation with responsibility for coastal management along the central southern coast of England.
Scour	Removal of underwater material by waves or currents, especially at the toe of a shore protection structure.
Sea level change	The rise and fall of sea levels throughout time in response to global climate and local tectonic changes.
Seawall	Massive structure built along the shore to prevent erosion and damage by wave action.
Sediment transport	The movement of a mass of sedimentary material by the forces of currents and waves.
Seiche	Standing wave oscillation in an effectively closed body of water.

Term	Definition
Significant wave height	The average height of the highest of one third of the waves in a given sea state.
SMP	Shoreline Management Plan. It provides a large-scale assessment of the risks associated with coastal processes and presents a policy framework to manage these risks to people and the developed, historic and natural environment in a sustainable manner.
SPA	Special Protection Area. These are internationally important sites, being set up to establish a network of protected areas for birds
SSSI	Sites of Special Scientific Interest. These sites, notified by English Nature (now Natural England), represent some of the best examples of Britain's natural features including flora, fauna, and geology. This is a statutory designation
Standard of Protection (SoP)	The level of return period event which the defence is expected to withstand without experiencing significant failure.
Storm surge	A rise in the sea surface on an open coast, resulting from a storm.
Sustainability (in coastal flood and erosion risk management)	The degree to which coastal flood and erosion risk management options avoid tying future generations into inflexible or expensive options for flood defence. This usually includes consideration of other defences and likely developments as well as processes within catchments. It will take account of long term demand for non-renewable materials.
Swash	The area onshore of the surf zone where the breaking waves are projected up the foreshore.
Swash aligned	A coastline that is orientated parallel to prevailing incident wave fronts.
Swell waves	Remotely wind-generated waves (i.e. Waves that are generated away from the site). Swell characteristically exhibits a more regular and longer period and has longer crests than locally generated waves.
SWL	Still water level. The level that the sea surface would assume in the absence of wind and waves.
SWRCMP	South West Regional Coastal Monitoring Programme (see PCO).
Thermohaline Circulation	Large-scale circulation in the ocean that transforms low-density upper ocean waters to higher-density intermediate and deep waters and returns those waters back to the upper ocean. The circulation is asymmetric, with conversion to dense waters in restricted regions at high latitudes and the return to the surface involving slow upwelling and diffusive processes over much larger geographic regions. The THC is driven by high densities at or near the surface, caused by cold temperatures and/or high salinities, but despite its suggestive though common name, is also driven by mechanical forces such as wind and tides.
Tide	Periodic rising and falling of large bodies of water resulting from the gravitational attraction of the moon and sun acting on the rotating earth.
Toe level	The level of the lowest part of a structure, generally forming the transition to the underlying ground.
Trigger level	Refers to levels that if reached, trigger a response. See Alarm Level and Crisis Level.

Term	Definition
UKCP09	UK Climate Projections 2009. Research giving predictions of how future climate change may affect the UK.
Wave climate	Average condition of the waves at a given place over a period of years, as shown by height, period, direction etc.
Wave diffraction	Process affecting wave propagation, by which wave energy is radiated normal to the direction of wave propagation into the lee of an island, breakwater or headland.
Wave direction	Direction from which a wave approaches.
Wave height	The vertical distance between the crest and the trough.
Wave hindcast	In wave prediction, the retrospective forecasting of waves using measured wind information.
Wave period	The time it takes for two successive crests (or troughs) to pass a given point.
Wave refraction	Process by which the direction of approach of a wave changes as it moves into shallow water.
Wave reflection	The part of an incident wave that is returned (reflected) seaward when a wave impinges on a beach, seawall or other reflecting surface.
WFD	Water Framework Directive. A European Directive that aims to establish a framework for the protection of inland surface waters (rivers and lakes), transitional waters (estuaries), coastal waters and groundwater.
World Heritage Site	A place of outstanding universal value. Designated by UNESCO (United Nations Educational, Scientific and Cultural Organisation).
WPBC	Weymouth & Portland Borough Council. Coastal Operating Authority as defined under the Coast Protection Act 1949 with permissive powers to provide defence against coastal erosion. <i>NB: The engineering services team of WPBC is provided jointly with West Dorset District Council.</i>

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