*Dawlish Warren & Exmouth Beach*
*Technical Appraisal Study*

# Exmouth Beach Management Plan

Prepared for
**East Devon District Council & Teignbridge District Council**

July 2015

CH2MHILL®
Ash House
Falcon Road, Sowton
Exeter, EX2 7LB
GB

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# Document History

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# Contents

**Appendices (all contained on accompanying CD)**

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# Executive Summary

This Beach Management Plan (BMP) covers the open coast frontage of Exmouth, Devon, located on the north side of the mouth of the Exe Estuary. The BMP frontage extends from Orcombe Point in the east to Exmouth Pier in the west. The area covered by this BMP is the responsibility of East Devon District Council (EDDC). In addition, Plymouth Coastal Observatory (PCO) undertakes coastal monitoring of the area as part of the South West Strategic Regional Coastal Monitoring Programme.

The aim of this BMP, which has been developed utilising best practice contained in the *CIRIA Beach Management Manual* (CIRIA, 2010), is to inform, guide and assist the responsible authorities and organisations in managing the beach and associated hard coastal defences, and to ensure that the risk of coastal flooding and erosion to properties and other assets along the Exmouth frontage continues to be managed sustainably, whilst recognising and managing the environmental and amenity implications of doing so.

The key objective of this BMP is to manage the risk of coastal flooding and erosion to property and other assets along the Exmouth frontage in the immediate future by ensuring that an adequate beach is maintained in support of the hard defence/control structures, alongside adequate maintenance of the hard defence structures themselves to ensure they remain in good to fair condition (refer to Section 1.3.4 and/or Appendix A).

The BMP sets out the plan for monitoring and intervention to maintain the beach and associated hard coastal defences to ensure they continue to provide adequate coastal flood and erosion risk management to Exmouth in the immediate future, whilst also identifying measures to develop and implement more sustainable longer-term solutions to the management of these issues. This monitoring and intervention plan has been developed in the context of providing a technically, economically, environmentally and socially sustainable management approach for the next 5 years (the BMP review period) in line with the long-term strategic coastal risk management approach adopted in 2013 as part of the *Exe Estuary Flood and Coastal Erosion Risk Management Strategy (EEFCERMS)*, which in turn aligns to the Shoreline Management Plan policies for this frontage that are set for a 100 year planning horizon, and which aim to 'Hold the Line' of existing defence along the Exmouth BMP frontage in the short, medium and long-term (refer to Section 1.7).

In developing the BMP, a key finding of the assessments made as part of the *Dawlish Warren and Exmouth Beach Recharge Technical Appraisal Study* (of which this BMP represents the final output) and the *EEFCERMS*, has been to identify that the preferred strategic option for Exmouth Beach is to involve annual recycling of approximately 6,000m$^3$ of sediment along the BMP frontage to commence within the next 10 years (by 2025) to increase the volume of the beach and its width along the Maer part of the frontage (BMP Management Unit 2). This would reduce the risk of low beach levels leading to undermining of the seawall and maintain the amenity value of the beach. Such recycling and recharge works would also need to be supported by ongoing maintenance of both the seawall along the BMP frontage, and of the timber groynes within BMP Management Unit 3 (Queen's Drive), with groynes eventually being replaced.

However, these assessments identified that the economic viability of delivering this preferred option is dependent on EDDC attracting a significant amount of Partnership Funding as central Government Flood Defence Grant in Aid is likely to only be available for about 15% of the total cost of this option calculated as part of the *EEFCERMS*. Therefore a key priority of the BMP is to establish Partnership Funding arrangements to ensure that the required implementation can be funded at the time it is needed in the most sustainable way, especially given plans for extensive redevelopment along the Queen's Drive part of the BMP frontage which will require ongoing coastal defence.

A further uncertainty with the preferred option is the availability of the amount of sediment to be recycled annually. Should this quantity prove to be difficult to achieve, then alternative options will need to be considered to ensure the risk of coastal flooding and erosion along the Exmouth frontage is managed sustainably and in line with long-term strategic policy to hold the line. These alternative

options would need to include consideration of construction of rock revetment and import of beach recharge from external source (possibly supported by construction of additional timber groynes). The future viability of such alternative options would in part also be determined by the amount of Partnership Funding EDDC is able to raise in the intervening years, thus further emphasising the importance of establishing funding partnerships in the immediate future.

Accepting these uncertainties, the monitoring and maintenance regime set out in Sections 4 and 5 of the BMP is intended to guide works that are required in the immediate future to maintain existing coastal defence assets in line with the adopted preferred strategy. Monitoring is targeted at both guiding when and where these maintenance works are needed (Alarm and Crisis trigger levels – Section 3.2.3) and capturing information that will be invaluable in providing evidence to advance present levels of understanding as part of future studies and BMP reviews. This monitoring regime will also provide valuable evidence for assessing the impacts of the Dawlish Warren Beach Recharge Scheme when it is constructed by the Environment Agency, which plans to extract sediment from Pole Sands and a point offshore of Orcombe Point and place it on the shoreline of Dawlish Warren on the opposite side of the mouth of the Exe Estuary from the Exmouth BMP frontage. The impacts of this dredging offshore of Exmouth will potentially increase wave exposure along the Exmouth frontage and so also affect the timing and/or frequency of future interventions at Exmouth, though not the nature of the interventions as defined in the maintenance regime of this BMP.

The Action Plan provided in Section 6 of this BMP provides a summary of the recommendations made throughout the BMP (identified with **bold underlined text**). The Action Plan identifies actions grouped by type as being either for ‘Monitoring’, ‘Maintenance’, ‘For Future Studies’. It is intended that this Action Plan be used to guide future management of this area.

# Glossary

| Term | Definition |
|---|---|
| Accretion | Accumulation of sediment due to the natural action of waves, currents and wind. |
| AIMS | Asset Information Management System. |
| Alarm Level | A Trigger Level. The level before Crisis Level. This is usually a predetermined value where the monitored beach parameter falls to within range of the Crisis 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 Alarm Level in this example is therefore a 5m buffer. Increased monitoring would be required when an Alarm Level is compromised and intervention undertaken if deemed necessary. Managing Alarm Levels can be planned in advance. |
| Amenity | The tangible or intangible elements of a location that contribute to a perceived positive character of the area for the enjoyment of those that use it. |
| Anthropogenic | General term used to describe the influence of man, e.g. the influence of sea defences or management actions on coastal processes. |
| APO | Annual probability of occurrence. |
| 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. |
| Bathymetry / Bathymetric (survey) | The measurement of depths of water in oceans, seas and lakes. Also the information derived from such measurements. |
| 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 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. |
| 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. |
| BMP | Beach Management Plan. It provides a basis for the management of the beach and defence asset system for flood and coastal erosion risk management purposes, taking into account coastal processes and the other uses of the coastal environment. |
| Breaching | Failure of the beach head allowing flooding by tidal action. |
| 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. |

| Term | Definition |
|---|---|
| Crisis Level | A Trigger Level. The level at which the function being monitored, such as the stability of the beach and/or any structures (seawall/promenade/groyne), could be compromised and emergency remedial action becomes necessary, e.g. as in the case described under Alarm 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. |
| Defra | Department for Environment, Food and Rural Affairs (formerly known as MAFF) |
| Devon County Council | Lead Local Flood Authority under the Flood and Water Management Act, 2010. |
| EA | Environment Agency. UK non-departmental government body responsible for delivering integrated environmental management including flood defence, water resources, water quality and pollution control. |
| EDDC | East Devon District Council. Coastal Operating Authority as defined under the Coast Protection Act 1949 with permissive powers to provide defence against coastal erosion. |
| Erosion | Wearing away of the land, usually by the action of natural forces. |
| FDGiA | Flood Defence Grant in Aid. The mechanism by which central Government funding for coastal flood defence and erosion protection works is accessed by operating authorities to deliver schemes. |
| 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. |
| 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. |
| GIS | Geographical Information System |
| Groyne | Narrow, roughly shore-normal structure built to reduce longshore currents, and/or to trap and retain beach material. Most groynes are of timber or rock, and extend from a seawall, or the backshore, well onto the foreshore and rarely even further offshore. |
| 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. |
| Hold the Line | An SMP policy to maintain or change the level of protection provided by defences in their present location. |
| $H_s$ | Significant wave height |
| 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. |
| 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. |
| 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. |
| mOD | metres Ordnance Datum. A universal zero point used in the UK, equal to the mean sea level at Newlyn in Cornwall. |
| 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. |

| Term | Definition |
|---|---|
| Mean Sea Level (MSL) | Average height of the sea surface over a 19-year period. |
| Mean High Water (MHW) | The average of all high waters observed over a sufficiently long period. |
| Mean High Water Springs (MHWS) | The average height of the high waters of spring tides. |
| Mean Low Water (MLW) | The average of all low waters observed over a sufficiently long period. |
| Mean Low Water Springs (MLWS) | The average height of the low waters of spring tides. |
| Met Office | UK Meteorological Office. |
| Monitoring | Systematic recording over time |
| 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. |
| 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. |
| Nearshore | The zone that extends from the swash zone to the position marking the start of the offshore zone, typically to water depths of about 20m. |
| NFCDD | National Flood and Coastal Defence Database. |
| 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. |
| Offshore | The zone beyond the nearshore zone where sediment motion induced by waves alone effectively ceases and where the influence of the seabed on wave action has become small in comparison with the effect of wind. |
| Overtopping | Water carried over the top of a coastal defence due to wave run-up exceeding the crest height. |
| Partnership Funding | A mechanism that provides funding in full or in part (alongside a proportion of total funding need from FDGiA) for coastal flood defence and erosion protection from multiple sources (including those that benefit directly from such measures). |
| PCO | Plymouth Coastal Observatory. Based at the University of Plymouth, responsible for the South-West Strategic Regional Coastal Monitoring Programme (SWRCMP). |
| 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. |
| Return Period | A statistical measurement denoting the average probability of occurrence of a given event over time. |
| Rock Armour | Wide-graded quarry stone normally bulk-placed as a protective layer to prevent erosion of the seabed and or other slopes by current and/or wave action. |
| Rock Revetment | A sloping surface of rock or stone used to protect a shoreline against erosion. |
| 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. |
| Scour | Removal of underwater material by waves or currents, especially at the toe of a shore protection structure. |

| Term | Definition |
|---|---|
| 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. |
| 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 |
| Spit | A long, narrow accumulation of sand or shingle, generally lying in-line with the coast, with one end attached to the land the other projecting into the sea or across the mouth of an estuary. |
| 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. |
| 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 Strategic Regional Coastal Monitoring Programme. Based at the University of Plymouth with Teignbridge District Council as lead authority (see also PCO). |
| 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 | This is usually a predetermined value where the monitored beach parameter falls to within range that results in management action being required (see also Action Level and Crisis Level). |
| UKCP09 | UK Climate Projections 2009. Research giving predictions of how future climate change may affect the UK. |
| UKHO | United Kingdom Hydrographic Office. |
| Wave climate | Average condition of the waves at a given place over a period of years, as shown by height, period, direction etc. |
| 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. |

| Term | Definition |
|---|---|
| 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. |

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# 1 Introduction

## 1.1 Background

This Beach Management Plan (BMP) covers the open coast frontage of Exmouth, Devon, located on the north side of the mouth of the Exe Estuary. The BMP frontage extends from Orcombe Point in the east to Exmouth Pier in the west and is split into three Management Units (MUs) as follows:

- MU1 – Western section
- MU2 – Central section
- MU3 – Eastern section.

These extents are shown in Figure 1-1.

The Exmouth frontage is at risk of both coastal flooding and erosion. To reduce these risks, coastal defences in the form of seawalls, timber groynes, beaches and (until winter 2013/14) sand dunes protect a large number of assets along the BMP extent. These assets include residential and commercial properties at Exmouth, which is home to approximately 47,800 residents (Devon County Council, 2011). In addition to properties, there are a number of listed buildings and structures dispersed throughout the Exmouth area. These have a variety of uses, including residential, commercial, general amenity, social, and shipping and public safety (including the RNLI lifeboat station and slipway at Queen's Drive). Due to the historic high value of tourism to Exmouth, there are also a number of amenity facilities along the shorelines, including hotels (and other accommodation types), restaurants, car parks and various entertainment facilities. The shoreline also forms part of the South West Coast Path.

The economic value of the assets protected along the Exmouth frontage that benefit from the continued protection against the risk of coastal flooding and erosion was calculated as part of the *Exe Estuary Flood and Coastal Erosion Risk Management Strategy (EEFCERMS)* as totalling in excess of £370m, although this is split across the BMP frontage as follows:

- BMP MUs 2 and 3 (correspond to EEFCERMS FCERM unit 02) = £19.2m.
- BMP MU 1 (corresponds to EEFCERMS FCERM unit 03) = £353.5m (NB: only a proportion of the BMP extent lies within the FCERM unit 03, and most of the benefits come from reducing flood risk along the Exe Estuary frontage of Exmouth rather than the open coast frontage that this BMP deals with).

(Atkins/Halcrow, 2013).

The preferred management option determined for the BMP extent in the EEFCERMS is to continue to provide flood and coastal erosion risk management measures, in the form of seawalls, timber groynes and beach management activities, along the open coast of Exmouth to maintain a required standard of protection of 0.1% Annual Probability of Occurrence (APO). Section 1.7.2 provides further detail.

It is the management of the coastal defences along the Exmouth BMP extent; in order to reduce the risk of coastal flooding and erosion to the assets at Exmouth in the immediate future in line with the long-term strategic aim; that this BMP defines. In doing so, the interaction between the beach and hard defences forms a key consideration within the BMP. The management regime defined in this BMP is also presented in the context of the wider environmental setting and amenity value of the beach environment to the local economy.

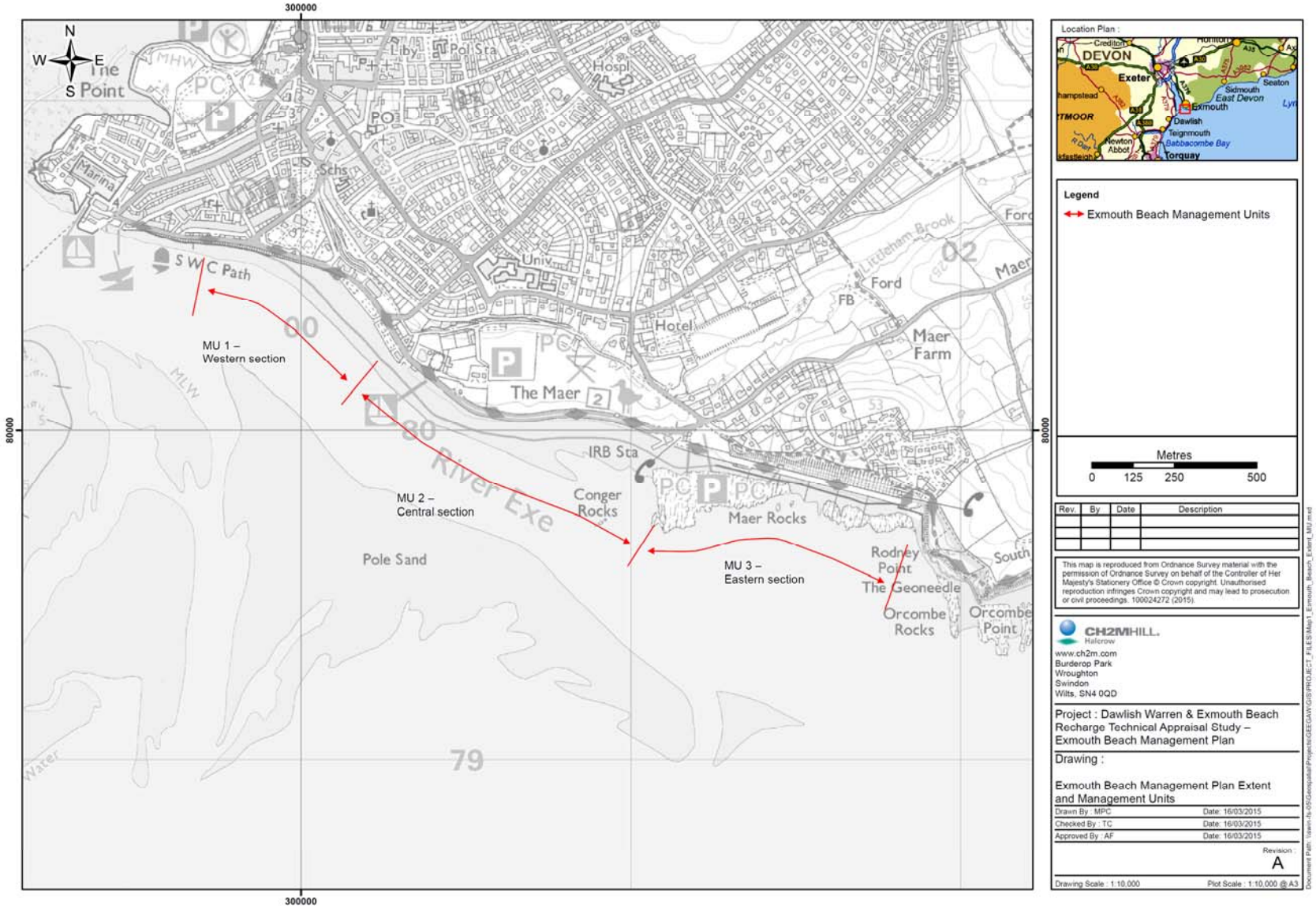


FIGURE 1-1
**Exmouth BMP extent and management units**

## 1.2 Objectives

The area covered by this BMP is the responsibility of East Devon District Council (EDDC). In addition, Plymouth Coastal Observatory (PCO) undertakes coastal monitoring of the area as part of the South West Strategic Regional Coastal Monitoring Programme.

The aim of this BMP, which has been developed utilising best practice contained in the *CIRIA Beach Management Manual* (CIRIA, 2010), is to inform, guide and assist the responsible authorities and organisations in managing the beach and associated hard coastal defences, and to ensure that the risk of coastal flooding and erosion to properties and other assets along the Exmouth frontage continues to be managed sustainably, whilst recognising and managing the environmental and amenity implications of doing so.

The key objective of this BMP is to manage the risk of coastal flooding and erosion to property and other assets along the Exmouth frontage in the immediate future by ensuring that an adequate beach is maintained in support of the hard defence/control structures, alongside adequate maintenance of the hard defence structures themselves to ensure they remain in good to fair condition (refer to Section 1.3.4 and/or Appendix A).

The BMP sets out the plan for monitoring and intervention to maintain the beach and associated hard coastal defences to ensure they continue to provide adequate coastal flood and erosion risk management to Exmouth in the immediate future, whilst also identifying measures to develop and implement more sustainable longer-term solutions to the management of these issues. This monitoring and intervention plan has been developed in the context of providing a technically, economically, environmentally and socially sustainable management approach for the next 5 years (the BMP review period) in line with the long-term strategic coastal risk management approach adopted in 2013 as part of the *EEFCERMS*, which in turn aligns to the Shoreline Management Plan policies for this frontage that are set for a 100 year planning horizon, and which aim to 'Hold the Line' of existing defence along the Exmouth BMP frontage in the short, medium and long-term (refer to Section 1.7).

The BMP also recommends what further studies may be appropriate to aid future coastal flood and erosion risk management in this area. 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. **These are to be reviewed in 5 years' time.**

## 1.3 Location

### 1.3.1 Environmental setting

The BMP extent along the open coast of Exmouth lies at the mouth of the Exe Estuary, Devon. The area is within a number of international and national environmental designations including the Exe Estuary SPA/Ramsar site and several SSSI's. The eastern end of the BMP area also represents the western limit of the Dorset and East Devon UNESCO World Heritage Site (the Jurassic Coast).

The Exe Estuary is also a designated shellfish water under the Shellfish Waters Directive with a thriving mussel industry. It is also a designated spawning ground for a number of fish species. Therefore it is important to maintain certain water quality standards within the estuary system. Water quality standards are also important for the bathing beaches in the area used for amenity. There are three designated bathing beaches within or in close proximity to the BMP area that are monitored under the Bathing Water Directive.

In addition, the area is designated locally for its landscape setting and character with the eastern part of the BMP extent being within the East Devon AONB. The town of Exmouth itself also includes several conservation areas as well as a number of listed buildings and non-designated archaeological sites.

Section 2.7 provides much more detail on these and other environmental features within and around the BMP area.

### 1.3.2 History of flooding and erosion

The Exmouth BMP frontage has a long history of coastal flooding and erosion. Literature reviewed as part of the *Devon Tidal Flood Warning Report* (Halcrow, 2009) in particular shows that between 1981 and 2008, there have been approximately 6 events whereby wave overtopping of the open coast defences at Exmouth (i.e. along the BMP extent) have resulted in flooding. Typically the flooding mostly affects the local highways with relatively few properties (1 to 3) apparently flooded each time.

In addition to wave overtopping, storms such as the ones that resulted in flooding at Exmouth also frequently result in the erosion of beach sediment from parts of the BMP frontage. Sediment is moved either alongshore or offshore (to the navigation channel) and can cause beach lowering which in turn poses risk of both increased wave overtopping and/or undermining of seawalls if levels are not able to recover before the next storm event. Further details on the beach response to storm events is provided in Section 2.6.3.

It has been in response to past flooding and erosion events that defences along the Exmouth BMP frontage have been constructed over the years, as described in Section 1.3.3.

### 1.3.3 Defence history

The western frontage of Exmouth Beach is protected by masonry sea walls and flood gates, which provide flood protection to Exmouth town. In the central section a small area of sand dunes along The Maer has also historically provided flood protection to parts of Queen's Drive and its hinterland along adjacent sections of Exmouth Beach. The eastern end of Exmouth is protected by a low vertical masonry wall fronted by timber groynes.

The Esplanade (west) (see Figure 1-2) is protected by a vertical masonry wall with a masonry apron to the western end. The masonry wall was constructed c.1960s and is considered to be in a good condition.

This Beach Gardens section (see Figure 1-2) is protected by masonry seawalls. This section is covered by three separate AIMS asset references. The far west defence consists of a masonry seawall with recurve fronted by a masonry revetment that was constructed c.1980. The central defence consists of a masonry seawall with parapet fronted by a masonry revetment constructed c.1970. The eastern defence of this section consists of a masonry seawall fronted by rock armour toe protection that was constructed c.1990. All of the defences within this section are in a good condition.

The Maer frontage (see Figure 1-2) has historically been protected by beach and sand dunes and is backed by a masonry seawall constructed c.1980. The seawall is currently in a good condition. However, the sand dunes have been all but lost to erosion as a result of extreme storm action over the winter 2013/14. As such, the seawall is now fronted primarily by a large beach and the remains of the sand dunes. It is likely that without dune management work, which was ceased by EDDC in 2012, this beach will gradually lower as sediment is moved along the rest of the BMP shoreline and this increasing the exposure of the seawall to wave action during extreme events.

The Queens Drive (east) section (see Figure 1-2) is protected by a vertical seawall backed by a promenade that was constructed c.1960. The beach along this section is controlled by 5 timber groynes. This eastern area is backed by high ground and the defences in this area serve to prevent coastal erosion.

Appendix A provides further details about the coastal defences along the Exmouth BMP frontage and their current condition.

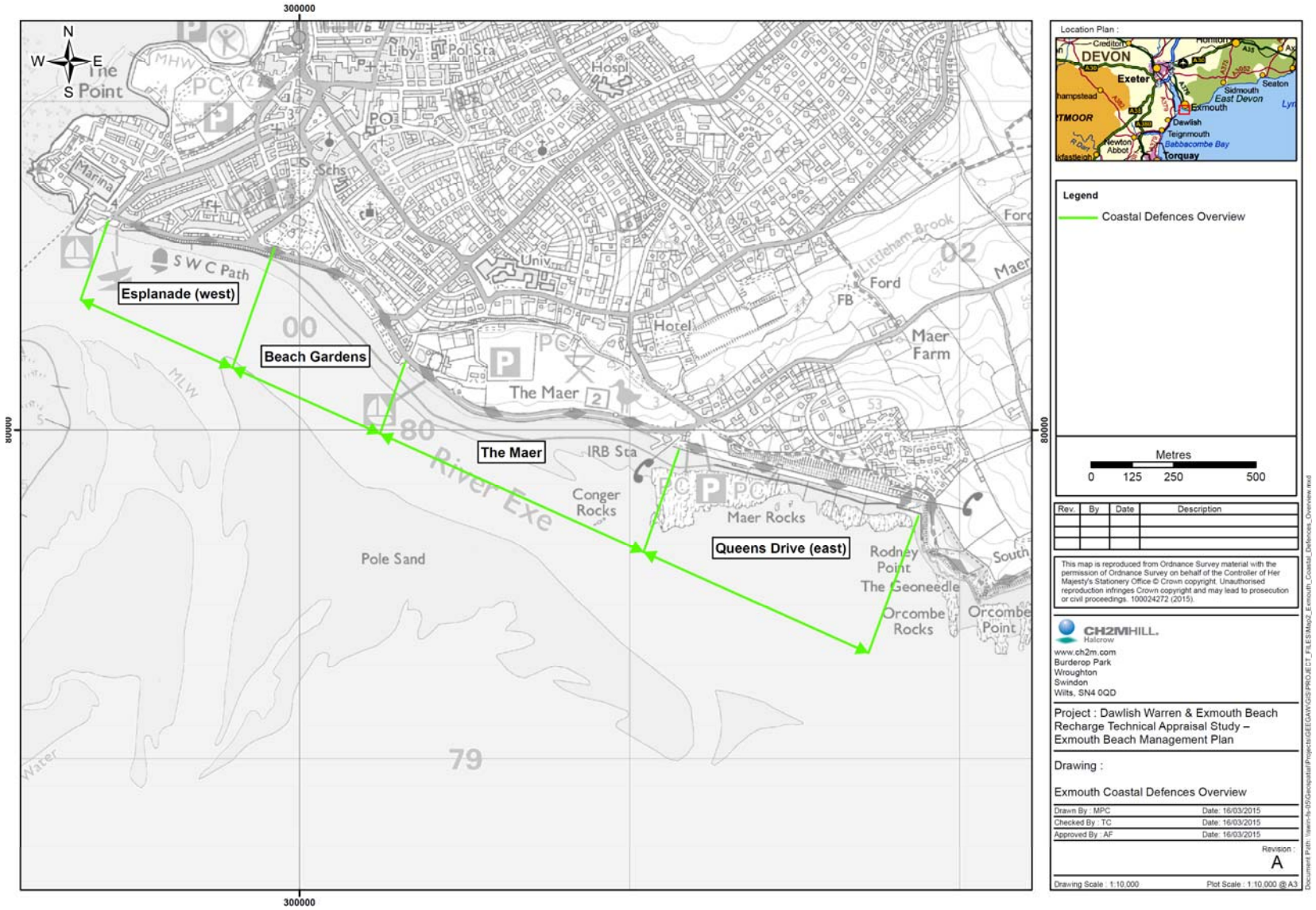


FIGURE 2-2
**Sections along the BMP frontage used in defence assessment**

### 1.3.4 Current defence condition

The coastal defence condition assessment undertaken as part of developing this BMP (see Appendix A), concluded that the hard defences along the Exmouth frontage are in good to fair condition with a typical residual life (with ongoing maintenance) of at least 45 years or more. The groynes along the frontage are also in good condition and estimated to have a residual life of 10-15 years if ongoing maintenance is carried out.

### 1.3.5 Amenity value

Tourism is an important industry of considerable economic value to the local community within the Exe Estuary. As it is based primarily on the attractive beaches, coastal scenery and countryside, tourism is predominantly seasonal (i.e. May to September) with the peak in August. Exmouth, along with Dawlish Warren on the opposite side of the Exe Estuary mouth, are the most popular tourist destinations; however, the beach and the sand dunes at these locations are currently eroding with an associated reduction in amenity value.

Exmouth is also popular with families due to the presence of a two mile long sandy beach, coastal walks and tourist attractions including a Pavilion. The BMP area is used for a variety of water-based activities with varying intensity of uses including boating, water-skiing, jet-skiing and power boating, canoeing, windsurfing, kitesurfing and sailing. Informal recreational pursuits in the BMP area include bird watching, golfing, picnicking, horse-riding, informal games, cycling and walking.

There are also water taxi trips from Exmouth to Dawlish Warren Point, this being the main entrance point to Dawlish Warren for tourists from Exmouth for visitors to then walk along the spit through the nature reserve to get to Dawlish Warren. The nature reserve at Dawlish Warren is popular, with 131,000 people a year who walk out onto the reserve (EA, 1995), including many visiting from Exmouth.

In addition much of the coastline forms part of the South West Coast Path, as shown in Figure 1-3.

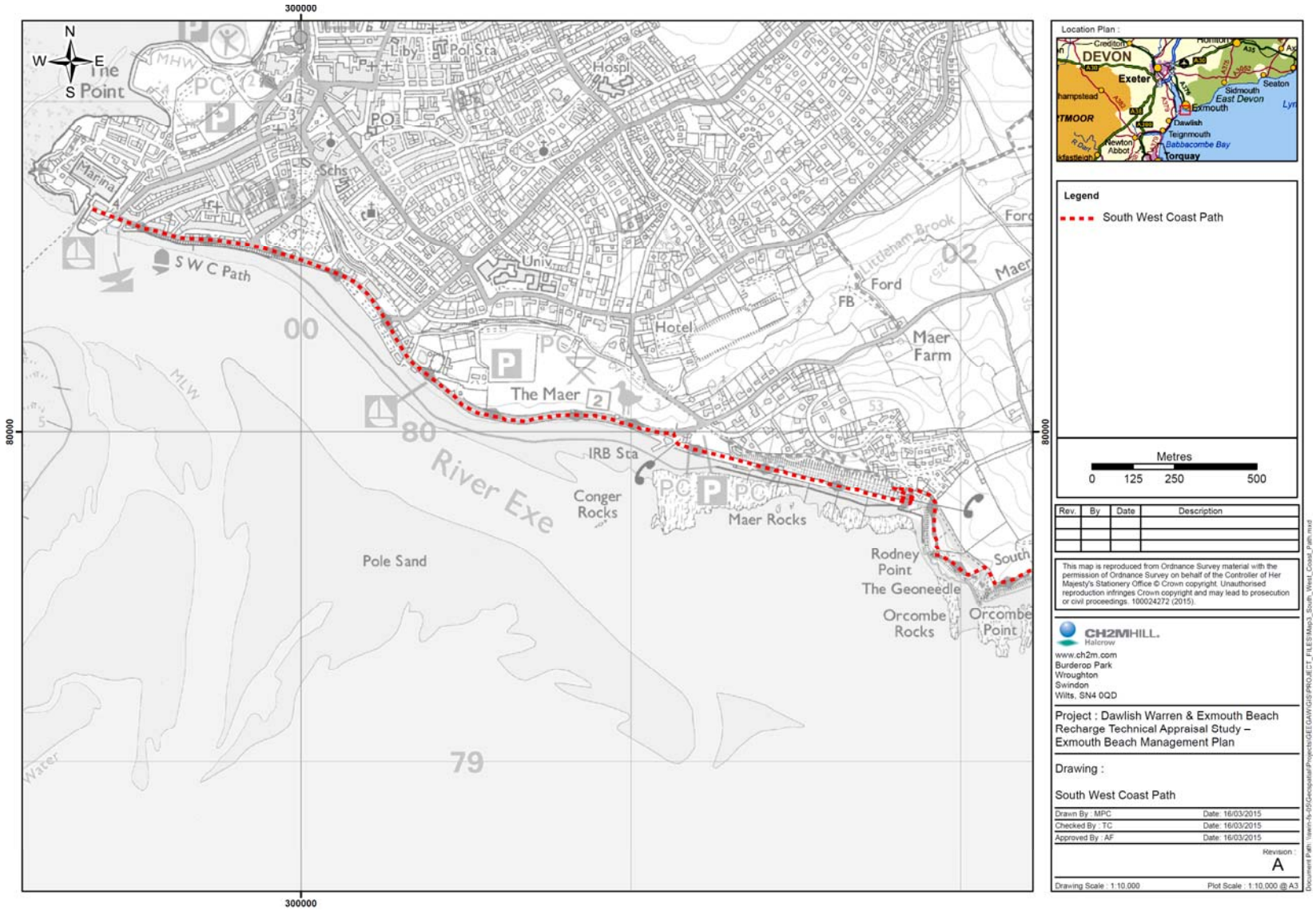


FIGURE 1-3
**South West Coast Path**

### 1.3.6 Land ownership

The coastal defence assets along the BMP area are the responsibility of EDDC. The land behind the defences is owned by a variety of public and private landowners, including EDDC (car parks) and the highways (Devon County Council).

### 1.3.7 Highways, services and utilities

The land behind the defences at Exmouth is primarily used for economic activity linked to the important tourism industry. There are a range of amenity facilities as well as local access roads and car parking facilities, notably at Queens Drive, which is owned and operated by EDDC.

At Queen's Drive/Maer's Rock there is an emergency storm water overflow outfall operated by South West Water. This is an overflow from the Maer Road pumping station and discharges 370 metres offshore. This overflow prevents local homes from being flooded with sewage after very heavy rainfall or emergency breakdown at the sewage pumping station. The operation of the overflow can lead to a drop in bathing water quality (Environment Agency, 2014).

Along the BMP frontage there is also a range of critical infrastructure including gas mains, combined sewer and surface water drainage pipelines that run beneath parts of the Exmouth promenade protected by the seawall.

## 1.4 Issues

### 1.4.1 Coastal flood and erosion risk management

The beach and hard defences along the BMP frontage protect against the risk of coastal flooding and erosion (see Figure 1-4).

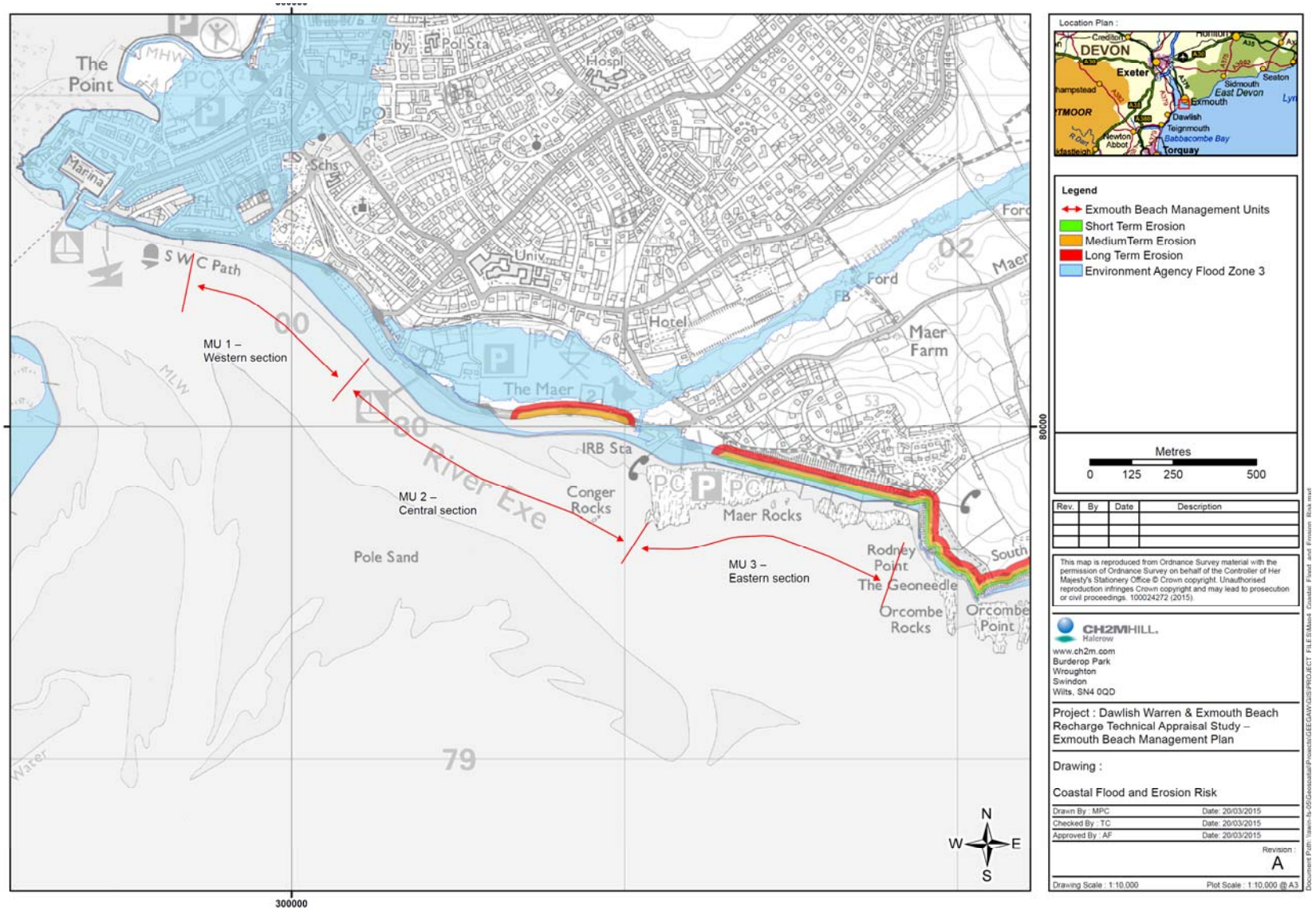


FIGURE 1-4
**Flood and erosion risk along the BMP frontage**

The current defence systems along these frontages (i.e. beach, groynes and seawalls in combination) have been constructed over a period of years since the 1960's (refer to Section 1.3.3). Analysis completed as part of this BMP indicates that there is a risk of these defences failing as a result of either wave overtopping or undermining due to scour during extreme events in the immediate future (refer to Appendices A and B). The main issue for these assets is therefore ensuring adequate maintenance and monitoring occurs to maintain their performance into the future.

The *EEFCERMS* concluded that any future management of flood and coastal erosion risk along much of the Exmouth BMP frontage (particularly BMP MUs 2 and 3) would be highly reliant upon the availability of Partnership Funding to enable access to central Government funding (FDGiA) that is estimated to only be available for about 15% of the total cost of implementing the preferred *EEFCERMS* option of beach recycling and timber groyne maintenance over the next 15 years. Section 1.7.2 provides further details about this.

As such, **measures should be taken by EDDC in the immediate future to establish a funding partnership to ensure that future delivery of any flood and coastal erosion risk management works at Exmouth can be both (a) delivered in a way that is preferred by the local communities (i.e. potentially fund beach recharge not just beach recycling) and (b) funded at the time when it is required and not depend solely on the availability (or lack thereof) of FDGiA funding**. This is especially important given plans for extensive redevelopment of the Queen's Drive part of the BMP frontage which will require ongoing coastal defence.

### 1.4.2 Environmental considerations

The following environmental considerations for beach management activities at Exmouth have been identified:

- Access and disturbance to recreational users as the beach is used extensively for amenity purposes - all works will need to be programmed to minimise the impact on amenity users by avoiding the peak holiday season, where possible. Also, there is a need to ensure safe public access during any possible works.
- Access for vehicles and personnel during the construction works.
- Noise/visual disturbance to residents/local businesses during construction works.
- Potential impact of the beach management activities the on landscape character.
- Potential impact on the non-designated archaeology features located along the BMP frontage.
- Potential impact on salmon migration and bass, lemon sole, sole and sprat spawning.
- There is a generic risk of unexploded ordnance which should be considered as part of a standard risk assessment.
- Risk of sediment turbidity adversely affecting designated shellfish within the Exe Estuary and bathing water quality at Exmouth (and other designated beaches in the area) during beach recycling/recharge works needs to be considered.
- Risk of pollutants in any sediment used to recharge the beach adversely affecting the bathing water quality.
- Risk of recharge sediment (if utilised in the future) being more angular than native beach sediment and thus being less 'attractive' from an amenity perspective.
- Risk of beach management works disrupting/altering sediment transport patterns around the mouth of the Exe Estuary.

### 1.4.3 Public safety and amenity considerations

In addition to the environmental related considerations identified in Section 1.4.2, the following public health and safety concerns were encountered during the site visit undertaken on 9th December 2014 (refer also to Appendix A). These are summarised as follows:

1. Provide permanent replacement for temporary access steps at points along Asset numbers 168679 and 113FAS3351002C02 (refer to Table 10 in Appendix A).
2. Remove exposed piles from 'groyne 7' adjacent Lifeboat slipway to improve safety for beach users, monitor exposed piles as beach levels change.

These were considered as part of developing the monitoring and maintenance regime presented in Sections 4 and 5 of this BMP.

### 1.4.4 Uncertainties about coastal processes

The detailed review of coastal processes was undertaken as part of both the *Dawlish Warren and Exmouth Beach Recharge Technical Appraisal Study* (of which this BMP represents the final output) and the *EEFCERMS* (refer also to Section 2). This generally provides a reasonable understanding of the coastal dynamics along the BMP frontage and the interactions with the sediment transport processes around the mouth of the Exe Estuary given the available data. However, there remain a number of uncertainties with regards current understanding of the processes occurring at the shoreline, and which will ultimately determine the future behaviour and therefore management of the beach. These are discussed below:

- The viability and sustainability of annually recycling c.6,000$m^3$ of sediment per year along the Exmouth frontage from areas of accretion to areas of erosion, as per the expectation of the preferred option adopted in the *EEFCERMS* (refer to Section 1.7.2) is based upon analysis of a short period of data. Further monitoring and analysis should help to clarify the longer-term trend and so how viable and sustainable this approach will be.
- The future evolution of the sand dunes along BMP MU2 is uncertain. These were severely eroded during the winter 2013/14 storms (refer to Section 2.6.3) and are thought unlikely to recover to their pre-storm condition naturally. It is more likely that sediment in this area will spread along the rest of the BMP frontage and beach levels in front of the seawall will gradually reduce to be similar to levels of the beach to the east and west of the sand dune area. Further regular monitoring and inspection of this area to assess recovery (or otherwise) will aid future management decisions, including whether or not to intervene and recycle sand from the sand dune area in MU2 eastwards into MU3 and undertake detailed monitoring to record what happens (refer to Section 5.2.3).
- The amount of sediment that actually enters the Exmouth BMP frontage from Sandy Bay could potentially be as much as 10,000$m^3$/yr (refer to Section 2.5.2). However, it is uncertain how much of this potential sediment input actually occurs. Further monitoring and analysis should help to clarify the longer-term trend and so how viable and sustainable this approach will be.
- The beach profiles span a number of months and the changes observed between successive surveys therefore encompass the cumulative effects of a number of events over the intervening periods. A more accurate assessment of the volumes of material lost during storms requires more frequent beach surveying. Ideally, this would include surveys being taken immediately before and after each storms. However, this is not always possible and an alternative would be to increase the frequency of surveys over the winter period when storms are likely to occur.

In addition to the above, there is also uncertainty about the impacts on the Exmouth BMP frontage that will result from the construction of the Dawlish Warren Beach Recharge Scheme by the Environment Agency. This scheme plans to extract sediment from Pole Sands and a second point offshore of Orcombe Point, and place it on the shoreline of Dawlish Warren on the opposite side of the mouth of the Exe Estuary from the Exmouth BMP frontage. The impacts of this dredging offshore of Exmouth will potentially increase wave exposure along the Exmouth frontage and so also affect the timing and/or frequency of future interventions at Exmouth, though not the nature of the interventions as defined in the maintenance regime of this BMP. As such, **it is vital to ensure that as part of the Dawlish Warren Beach Recharge Scheme, that funding of detailed and ongoing monitoring along the Exmouth frontage and of the nearshore area is implemented in line with the monitoring requirements defined in Section 4 of this BMP**.

## 1.5 Responsibilities for management

Responsibility for the management and operation of activities along the BMP frontages varies depending upon the activity and ownership. Table 1-1 summarise the roles and responsibilities.

TABLE 1-1
**Assigned responsibilities for coastal flood and erosion risk management activities at Exmouth.**

| **Management Activity** | **Assigned Responsibility** *(note, responsibility varies along the frontage for some management activities)* |
|---|---|
| Monitoring of beach and other coastal processes | South West Coastal Monitoring Group |
| Initiation of post-storm surveys | East Devon District Council |
| Operations to maintain beach profile | East Devon District Council |
| Cleaning/clearance of promenades/backing roads etc of beach debris for amenity. | East Devon District Council |
| Cleaning/clearance of beach in response to pollution incidents. | East Devon District Council or Devon County Council *(depending on nature of hazard)* |
| All structural inspection and maintenance of promenade, seawall, timber groynes that form part of the formal coastal defences | East Devon District Council |
| All inspection and maintenance of access steps and ramps to beach from seawalls/promenades that form part of the formal coastal defences | East Devon District Council |
| All inspection and maintenance of RNLI slipway | RNLI |
| All maintenance of footpath and cycleways including signs for designated public footpaths and rights of way. | Devon County Council |
| Litter clearance | East Devon District Council |
| Maintenance of seats, litter bins etc | East Devon District Council |
| Provision of signage | East Devon District Council / Devon County Council |
| Flood warning | Environment Agency |
| Flood incident response actions | Environment Agency and Devon County Council |
| Emergency planning | East Devon District Council, Environment Agency and Devon County Council |

Actual ownership of the assigned responsibility for each management operation identified in Table 1-1 is in some cases held by different departments within the identified organisation. Therefore, in order to support Table 1-1 and to provide clarity on who should be contacted for each item, Appendix C provides more specific contact details for those responsible for each management operation. Appendix C also contains contact details for some of the other key stakeholders who do not have a direct management role along the BMP frontage but who are likely to be key contacts for future studies and schemes.

# 1.6 Licences, approval and consents

In order to undertake any future beach recycling, beach recharge or other capital scheme along the Exmouth BMP frontage as described in Section 5, a range of licences, approvals and consents will be required, including:

- Marine Licence under the Marine and Coastal Access Act 2011
- Planning Application under the Town and Country Planning Act 1990.

The following sections summarise the required consents 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 addressed in order to minimise the risk of delays in being able to implement works. These discussions should also assess the applicability of progressing a 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 frontage no Marine Licence is held to facilitate the beach management works envisaged to be implemented within the next 10 years (between 2020 and 2025) to fulfil the preferred strategy adopted in the *EEFCERMS*. As such, as part of any future scheme development to implement beach recycling or any other works along the BMP frontage, the Marine Management Organisation (MMO) will need to be engaged to seek a Marine Licence to facilitate this.

As part of the process of obtaining a Marine Licence for undertaking beach recharge or other capital works, consideration of the Marine Work (Environmental Impact Assessment) Regulations 2007 will also be needed 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 Assessment may also be required to support the 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 a Marine Licence application. The Competent Authority for this would be Natural England.

**It is strongly recommended that a Scoping Opinion be sought from the MMO in the immediate future to determine if a Marine Licence is required for beach recycling and, if needed and given the time-scale involved in obtaining a Marine Licence (typically 14 weeks), obtain a Marine Licence from the MMO in good time to enable beach management 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 prior to the planned works between 2020 and 2025.

## 1.6.2 Planning Application

Any capital scheme will also require some form of planning consent from EDDC. It is recommended that the local planning officer be consulted at the time when a capital scheme is 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, EDDC would likely act as the Competent Authority.

# 1.7 Linkages to other relevant documents

## 1.7.1 Shoreline Management Plan policy

The current Shoreline Management Plan (SMP) covering the Exmouth BMP frontage was adopted in June 2011 (Halcrow, 2011). The SMP policy recommended for this section of coast is primarily to 'Hold the Line' for the next 100 years. There is, however, the potential for some 'Managed Realignment' along The Maer in the medium term, subject to more detailed studies in the short term.

Table 1-2 summarises the SMP policies that apply to the BMP area.

Table 1-2

**SMP Policies adopted June 2011 (from Halcrow, 2011) along the BMP area**

| Policy Unit | Short Term (to 2025) | Medium Term (to 2055) | Long-term (to 2105) |
|---|---|---|---|
| 6a44 – Orcombe Rocks to Maer Rocks | Maintain existing defences under a **Hold the Line** policy to provide continued protection to Exmouth. | Continue to maintain existing defences under a **Hold the Line** policy. | Continue to maintain existing defences under a **Hold the Line** policy. |
| 6a45 – The Maer | Continue to maintain existing defences under a **Hold the Line** policy to provide continued protection to Exmouth. Investigate possibility of realignment. | Implement Managed Realignment through constructing a set-back defence if detailed study finds it is appropriate to do so. Continue to maintain and improve defences under a **Hold the Line** policy if realignment is not found to be appropriate. | **Hold the Line** of defence, either along existing or realigned extents. |
| 6a46 – Harbour View to Exmouth Pier | Continue to maintain existing defences under a **Hold the Line** policy to provide continued protection to Exmouth. | Continue to maintain existing defences under a **Hold the Line** policy. | Continue to maintain existing defences under a **Hold the Line** policy. |
| 6a47 – Exmouth Spit | Continue to maintain existing defences under a **Hold the Line** policy to provide continued protection to Exmouth. | Continue to maintain existing defences under a **Hold the Line** policy. | Continue to maintain existing defences under a **Hold the Line** policy. |

## 1.7.2 Exe Estuary Flood and Coastal Erosion Risk Management Strategy, 2013

The *EEFCERMS* was completed and adopted in 2013 (Atkins/Halcrow, 2013). This developed and tested the policies set in the SMP2 (refer to Section 1.7.1) for the Exe Estuary, including the open coast to Straight Point in the east and Langstone Rock to the west.

In regards to the Exmouth BMP frontage, the *EEFCERMS* preferred option is defined across the Flood and Coastal Erosion Risk Management (FCERM) Units, namely:

- FCERM 02 – The Maer (extending from Orcombe Rocks in the east to the Lookout Station along Exmouth seafront; i.e. BMP MUs 2 and 3); and
- FCERM 03 – Exmouth (extending westwards from the Lookout Station and into the Exe Estuary; i.e. part of BMP MU 1).

The development of the *EEFCERMS* tested the SMP2 policy for potential managed realignment along SMP2 PU 6a45 (The Maer) and concluded this was not viable, particularly given the plans of EDDC to redevelop the Queen's Drive area of the frontage. As such, the policy for this SMP2 unit is confirmed as being Hold the Line in each epoch of the SMP2. Having concluded this, the *EEFCERMS* went on to determine the following as preferred strategic approach for the Exmouth BMP extent:

- FCERM 02 [BMP MUs 2 and 3]: undertake monitoring of beach levels from 2015 onwards with an expectation to recycle about 6,000m$^3$/yr of beach sediment from areas of accretion to areas of erosion between 2020 and 2025 to reduce the risk of lowering beach levels impacting on the standard of protection against wave overtopping and/or scour and undermining of the seawall. This is to be supported by maintenance of the timber groynes [located in BMP MU1]. The economic case for this approach is reliant on Partnership Funding as the *EEFCERMS* calculated that only about 15% of the funding for beach recycling and groyne maintenance would be available via central Government's Flood Defence Grant in Aid (FDGiA) (i.e. FDGiA expected to provide c.£400k towards total cost estimated to be c.£2,900k over the next 15 years, therefore at least c.£2,500k of funding needs to be raised from non-FDGiA sources – refer also to Section 1.4.1). For this reason, the *EEFCERMS* also concluded there is insufficient economic justification to undertake beach recharge at the present time, which would be an even more costly operation, unless an even greater level of non-FDGiA funding can be raised.
- FCERM 03 [BMP MU1]: undertake monitoring of beach levels. Potentially increase the crest height of the seawall at some point in the future to maintain the required standard of protection against wave overtopping and associated flood risk as sea levels rise. There is sufficient economic justification for this approach as it supports management of flood risk from both the open coast and estuary frontages of Exmouth to about 1,800 properties at the present day, increasing to about 2,700 properties over the next 100 years allowing for the impacts of sea level rise.

The monitoring and maintenance regime defined in Sections 4 and 5 of this BMP respectively, have been developed to support the implementation of these preferred strategic options adopted in the *EEFCERMS*, which in turn were in part informed by the options appraisal carried out for the *Dawlish Warren and Exmouth Beach Recharge Technical Appraisal Study* (of which this BMP represents the final output) that is provided in Appendix D of this BMP for future reference.

### 1.7.3 The East Devon New Local Plan 2006-2026

The East Devon New Local Plan is currently in draft and will supersede the current Local Plan (1995-2011). It has been submitted for examination so the commentary below reports on propose relevant strategies and polices. The introduction to the Plan sets out the aim of the plan to guide where development in East Devon will occur and how the great natural asset will be conserved and enhanced. Pertinent strategies and policies are identified below:

- Strategy 5 – Environment
- Strategy 22 – Development at Sidmouth
- Strategy 44 – Undeveloped coast and coastal Preservation Areas
- Strategy 45 – Coastal erosion
- Strategy 46 – Landscape conservation and enhancement and AoNB
- Strategy 47 – Nature conservation and geology
- Policy EN4 – Protection of Local Nature Reserves, County Wildlife Sites and County Geological Sites
- Policy EN5 – Wildlife habitats and features
- Policy EN6 – Nationally and locally important archaeological sites
- Policy EN7 – Proposal affecting site which may potentially be of archaeological importance
- Policy EN10 – Preservation and enhancement of conservation areas
- Policy EN15 – Environmental impacts, nuisance and detriment to health
- Policy EN18 – Maintenance of water quality and quantity
- Policy EN21 – River and coastal flooding
- Policy EN23 – Coastal erosion and surface water run-off
- Policy EN24 – Coastal Defence Schemes
- Policy EN25 – Development affected by coastal change
- Policy TC4 – Footpaths, Bridleways and cycleways.

### 1.7.4 East Devon Area of Outstanding Natural Beauty (AONB) Management Strategy 2014-2019

The East Devon AONB management strategy contains a number of objectives and policies deriving from three main themes 1. Landscape 2. Sustainability 3. Communication and Management and 12 sub-themes. Objectives and policies relevant to the Exmouth BMP are detailed below with sub-themes presented in bold:

- **Coast** – Objective: The conservation and enhancement of the high quality and international significant coastline. Policy: (C 1) Conserve and enhance the tranquil, unspoiled and undeveloped character of the coastline and estuaries and encourage improvements to coastal sites damaged by past poor quality development or intensive recreational pressure.
- **Planning and Development** – Objective Planning development and policy protects the special landscape character and tranquillity of the AONB and will enable appropriate forms of social and economic development that are compatible with the landscape, so conserving and enhancing the environment. (P 3) Encourage the development of guidelines and design guides to support high quality sustainable development which complements and respects the AONB landscape and historic character.

# 2 Supporting Information

This section of the BMP provides a summary of the physical setting of the BMP around the mouth of the Exe Estuary. The aim of this summary is to provide an overview of the coastal processes affecting the Exmouth Beach frontage and the impacts of human intervention upon them, as well as details of the environmental features of the site that must be considered when undertaking beach management in this area. This includes the following information:

- Wave climate (typical waves, extreme waves).
- Water level climate (tidal information, extreme water levels).
- Joint probability extreme wave and water levels.
- Climate change.
- Sediment transport (sediments, shoreline movement, beach stability).
- Environmental characteristics.

This summary is largely based upon detailed assessment undertaken as part of developing the *EEFCERMS* (Atkins/Halcrow 2013) and the outputs of the numerical modelling work undertaken as part of this *Dawlish Warren and Exmouth Beach Recharge Technical Appraisal Study* project (Appendix E).

## 2.1 Wave climate

### 2.1.1 Typical waves

The dominant wave direction in this part of the English Channel is from the south-west (Defra, 2002). At Exmouth, the dominant wave direction is from the south-east. The SMP (Halcrow, 2011) suggests that because the Exmouth coastline faces southwards, it is rarely exposed to waves from the Atlantic, other than those that are diffracted around Start Point. Therefore, exposure to waves from the east and south-east is more significant. Even then, Pole Sand serves to limit the extent of wave action along the Exmouth BMP frontage.

Recorded wave climate data for the area is limited, however between February and March 2008, wave data was recorded at two points around the entrance of the Exe Estuary. This data is described in Section 2.2.1 of the numerical modelling report (see Appendix E).

More recently, wave climate data has been recorded by the Dawlish Directional Waverider Buoy, operated as part of the South West Strategic Regional Coastal Monitoring Programme (SWRCMP). This is located approximately 3.5km south of Exmouth, and provides a record of wave height for the period between 7$^{th}$ December 2010 and 30$^{th}$ April 2014. A plot of the wave height data in Figure 2-1 shows that the predominant wave direction in this area is from the south and south-east.

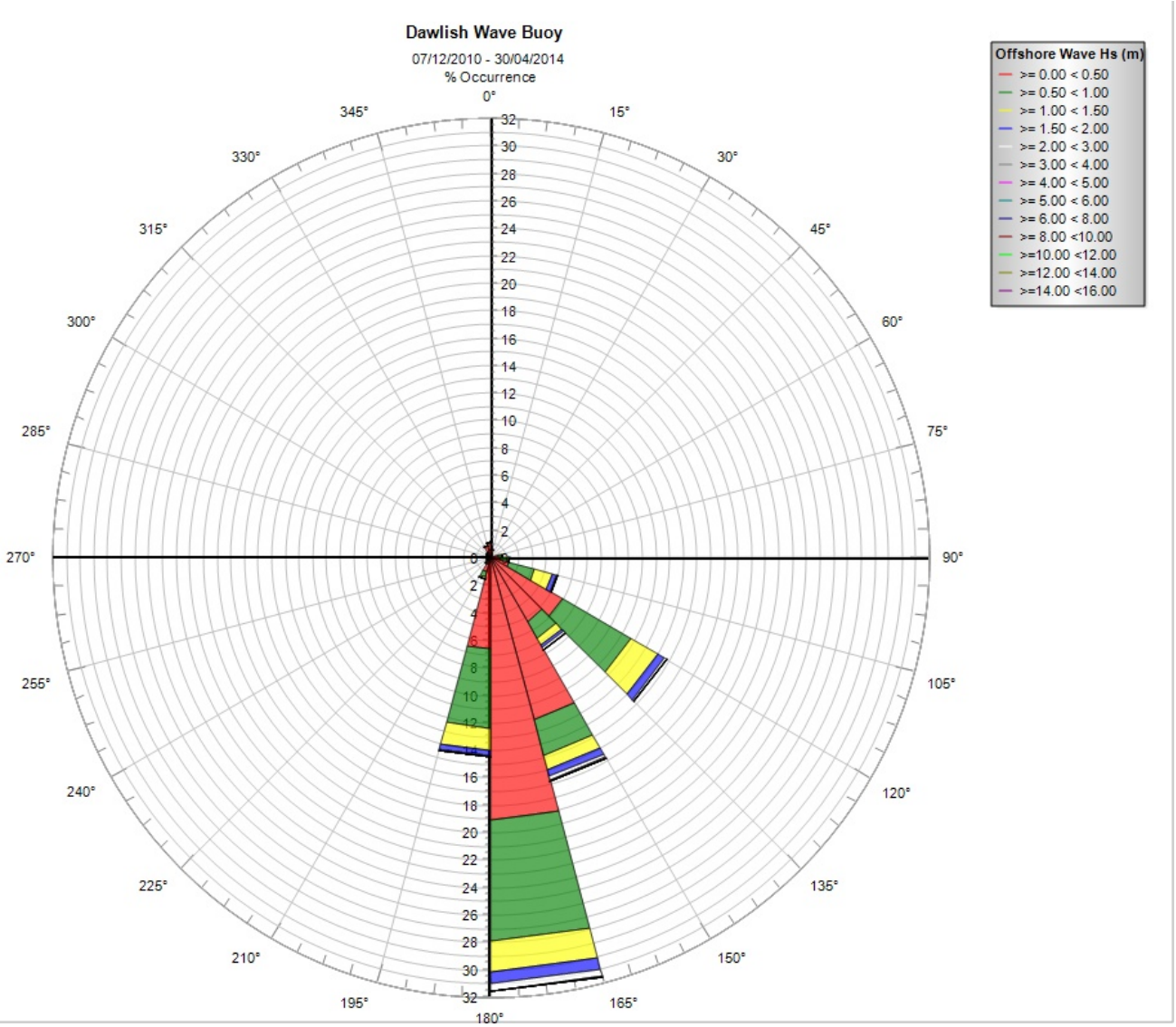


FIGURE 2-1
**Offshore wave height recorded by the Dawlish Directional Wave Buoy between 7/12/2010 and 30/04/2014 (PCO, 2013).**

### 2.1.2 Extreme waves

Extreme wave climate was defined as part of the *EEFCERMS* work (Atkins/Halcrow 2013) and is summarised for the Exmouth BMP frontage in Table 2-1.

TABLE 2-1
**Extreme wave climate (significant wave height, m) for Exmouth BMP frontage (Atkins/Halcrow, 2013).**

| Return period, AEP % (1 in X years) | 100% (1:1) | 20% (1:5) | 10% (1:10) | 5% (1:20) | 2% (1:50) | 1% (1:100) | 0.5% (1:200) | 0.1% (1:1000) |
|---|---|---|---|---|---|---|---|---|
| **Significant wave height, Hs** | 2.39 | 2.44 | 2.48 | 2.50 | 2.52 | 2.54 | 2.55 | 2.55 |

## 2.2 Water levels

### 2.2.1 Tidal information

The Exe Estuary is macro-tidal (a tidal range between 1.2m to 4.5m). The tidal range at Exmouth is between 1.5m and 3.8m (neaps and springs respectively). Normal tide levels for the Exmouth

(Approaches) and Exmouth Docks, which are the two relevant points for the BMP frontage are provided in Table 2-2.

TABLE 2-2
**Tide levels relevant to Exmouth BMP frontage from the 2015 Admiralty Tide Tables (UKHO, 2014).**

| Tide Level (mOD) for Tidal Condition | Exmouth (Approaches) | Exmouth Docks |
|---|---|---|
| HAT | - | - |
| MHWS | 2.16 | 2.17 |
| MHWN | 0.96 | 0.97 |
| MSL | 0.07 | 0.27 |
| MLWN | -0.74 | -0.53 |
| MLWS | -1.94 | -1.63 |
| LAT | - | - |
| ***mOD to mCD conversion*** | ***+2.44*** | ***+1.83*** |

### 2.2.2 Extreme water levels

The most recent estimate of extreme tide levels for this area is provided by the Environment Agency's R&D project 'Coastal Flood Boundary Conditions for UK Mainland and Islands' (Environment Agency, 2011a). The data relevant to the frontage at Exmouth is shown in Table 2-3. This is the same data utilised in the *EEFCERMS* (Atkin/Halcrow, 2013).

TABLE 2-3
**Extreme tide levels for a range of return periods at Exmouth (Environment Agency, 2011a).**

| **Return period, AEP% (1 in X years)** | 100% (1:1) | 20% (1:5) | 10% (1:10) | 5% (1:20) | 2% (1:50) | 1% (1:100) | 0.5% (1:200) | 0.1% (1:1000) |
|---|---|---|---|---|---|---|---|---|
| EWL (mOD) | 2.74 | 2.90 | 2.97 | 3.06 | 3.13 | 3.20 | 3.27 | 3.46 |

## 2.3 Joint probability extreme waves and water levels

The most recent Joint Probability Analysis (JPA) of extreme wave and water level conditions for the study area was carried produced as part of the *EEFCERMS* (Atkins/Halcrow, 2013). This JPA data (provided in full in Table 2-4) was calculated for a point along the Exmouth BMP frontage using the simplified JPA method (Defra/Environment Agency, 2005).

TABLE 2-4
**Joint probability extreme wave and water levels for a range of return periods at Exmouth (Atkins/Halcrow, 2013).**

| | Joint Probability Wave Heights (m) by Return Period AEP % (1 in X years) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Extreme Water Level (mOD) | 100% (1:1) | 20% (1:5) | 10% (1:10) | 5% (1:20) | 2% (1:50) | 1% (1:100) | 0.5% (1:200) | 0.1% (1:1000) |
| 1.84 | 2.20 | 2.24 | 2.30 | 2.32 | 2.34 | 2.35 | 2.36 | 2.39 |
| 1.99 | 2.20 | 2.24 | 2.30 | 2.32 | 2.34 | 2.35 | 2.36 | 2.39 |
| 2.14 | 2.15 | 2.20 | 2.30 | 2.32 | 2.34 | 2.35 | 2.36 | 2.39 |
| 2.29 | 2.12 | 2.16 | 2.28 | 2.31 | 2.33 | 2.35 | 2.36 | 2.39 |
| 2.44 | 2.08 | 2.13 | 2.25 | 2.28 | 2.32 | 2.34 | 2.35 | 2.39 |
| 2.59 | 2.03 | 2.08 | 2.19 | 2.25 | 2.29 | 2.32 | 2.34 | 2.37 |
| 2.74 | 1.98 | 2.04 | 2.15 | 2.21 | 2.27 | 2.30 | 2.33 | 2.36 |
| 2.82 | | 2.00 | 2.12 | 2.17 | 2.24 | 2.28 | 2.31 | 2.35 |
| 2.90 | | | 2.07 | 2.12 | 2.19 | 2.24 | 2.28 | 2.34 |
| 2.97 | | | 2.03 | 2.09 | 2.15 | 2.20 | 2.25 | 2.33 |
| 3.06 | | | | 2.05 | 2.12 | 2.16 | 2.22 | 2.31 |
| 3.13 | | | | | 2.06 | 2.12 | 2.16 | 2.28 |
| 3.20 | | | | | | 2.08 | 2.13 | 2.25 |
| 3.27 | | | | | | | 2.09 | 2.21 |
| 3.46 | | | | | | | | 2.12 |

## 2.4 Climate change and 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 were calculated as part of the *EEFCERMS* (Atkins/Halcrow, 2013) and are presented in Table 2-5 for ease of reference as this remains the current guidance. 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.
- 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 Exmouth. *See text above for an explanation of the 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 | Upper End Estimate + Surge Estimate |
| 2010 to 2030 | +0.065 | **+0.114** | +0.095 | +0.295 |
| 2010 to 2060 | +0.178 | **+0.317** | +0.345 | +0.695 |
| 2010 to 2110 | +0.410 | **+0.750** | +1.015 | +1.715 |

# 2.5 Sediment transport

## 2.5.1 Sediments

The Exe Estuary was infilled with sediment as the Exe River Valley became flooded by rising sea levels during Holocene marine transgression (c.10,000 years BP to present). Assessment made as part of the *EEFCERMS* (Atkins/Halcrow, 2013) concludes that sediment input to the system is now finite with only limited inputs from cliff erosion (i.e. from Sandy Bay) and storm events (see Section 2.5.2).

In relation to the Exmouth BMP frontage, the sediments located around the mouth of the Exe Estuary system vary from mixed sand and gravel in the beach and nearshore banks to sandy in the nearshore, sub-tidal areas and offshore.

This is verified to an extent by Sediment grab samples collected by analysis of a number of grab samples collected and analysed as part of this recharge technical appraisal project. This sediment grain size analysis is reported in Appendix F and indicates a $D_{50}$ range of sediment grain size as being between 0.24mm (sand) and 11mm (gravel). However, it is important to note that these samples were taken from the navigation channel and Pole Sands areas only, and not along the Exmouth BMP frontage, so are only an indication of the sediment along the BMP extent. Further sampling and analysis of sediment along Exmouth Beach would be needed to provide site specific data.

## 2.5.2 Sediment transport mechanisms

Sediment movements in and around the Exe Estuary including the Exmouth BMP frontage are complex. These processes were investigated in detail as part of numerical modelling (see Appendix E). The findings of that modelling are summarised in Figure 2-2.

The information from this numerical modelling was used along with other data and analysis to develop a conceptual model of sediment transport processes movements in and around the Exe Estuary, including an approximate sediment budget, as part of the *EEFCERMS* (Atkins/Halcrow, 2013). This conceptual model is shown in Figure 2-3. The key element of this conceptual model with regards the Exmouth BMP frontage as summarised in Atkins/Halcrow (2013) is that the beaches along Exmouth are eroding, with

sediment losses of around 6,000$m^3$/yr. The mechanism for beach erosion is wave action during storms which cause the erosion of the upper beach and the transport of material alongshore and offshore. This material either passes into the estuary mouth and thence into the sub-tidal banks or is combed down into the ebb tidal delta (Pole Sands) directly. Once sediment enters the ebb tidal delta system it becomes subjected to tidal processes which redistribute sediment between the flood and ebb tidal delta. This loss of sediment from Exmouth Beach is potentially mitigated to a degree input of c.10,000$m^3$/yr of sediment from Sandy Bay (derived from erosion of Orcombe Cliffs) as this sediment can potentially be completely transported westward to Exmouth Beach.

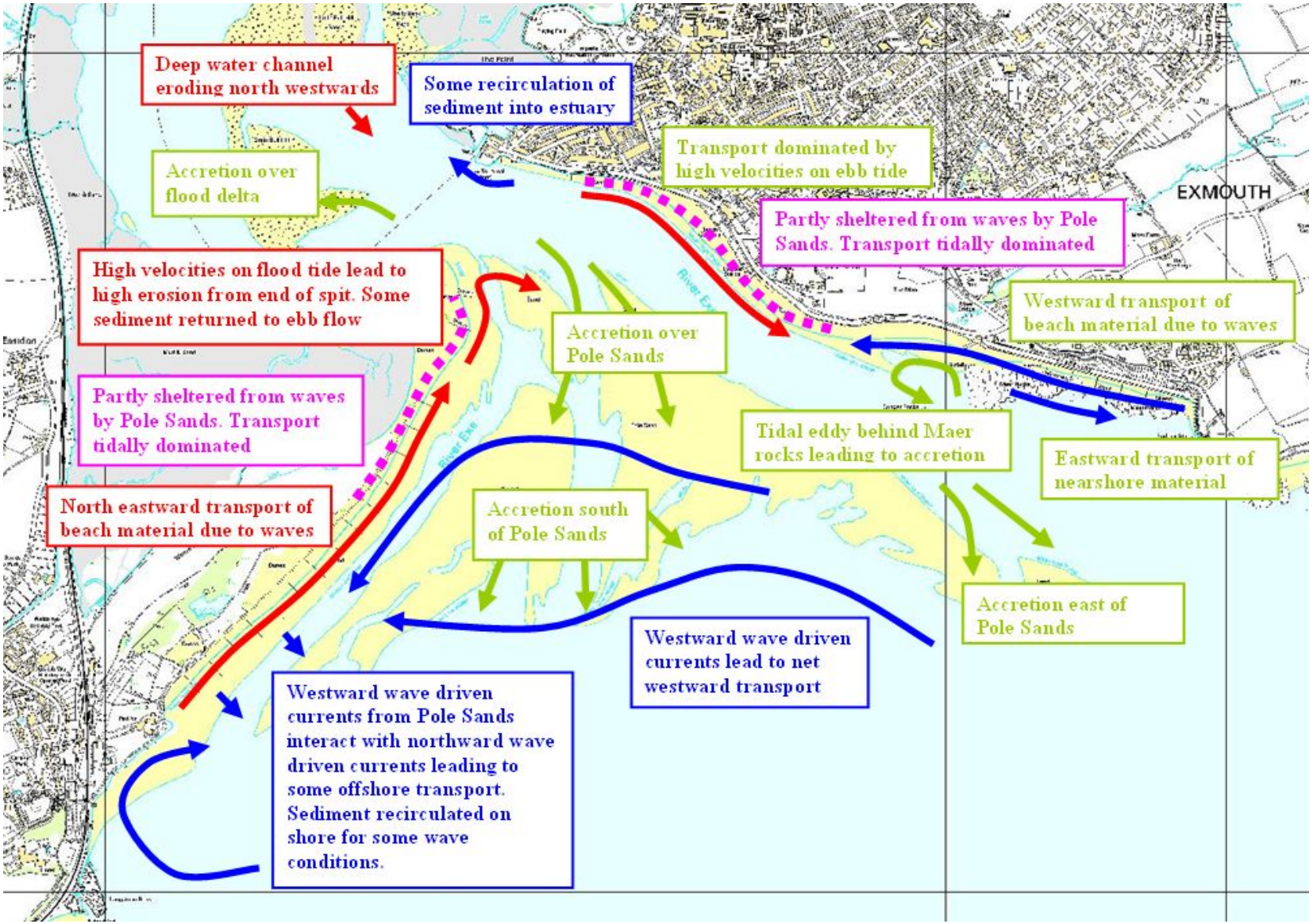


FIGURE 2-2
**Summary of sediment transport processes around the mouth of the Exe Estuary based on findings from numerical modelling (see Appendix E).**

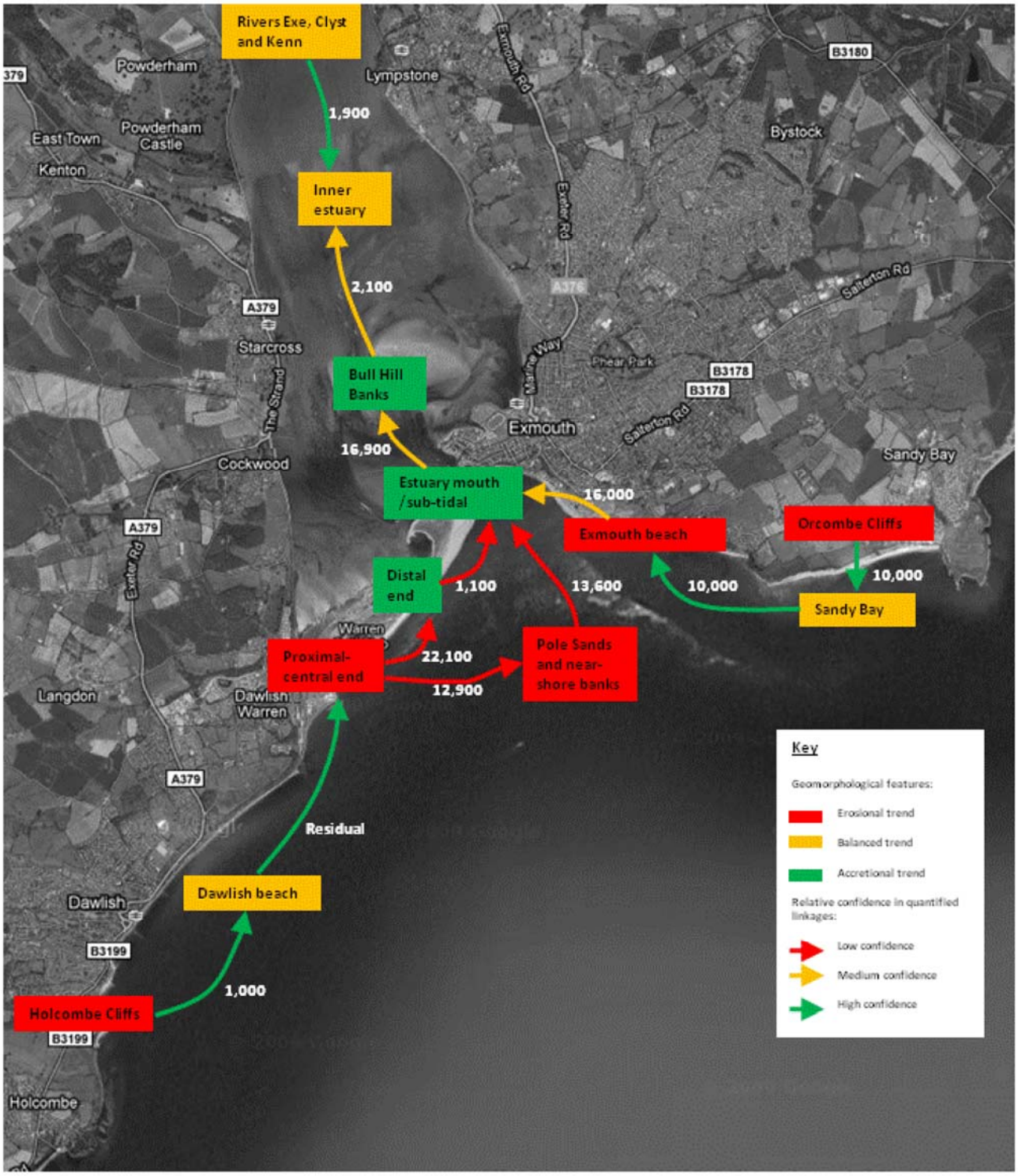


FIGURE 2-3
**Conceptual model of the Exe Estuary with quantified net sediment exchanges ($m^3$/year) (from Atkins/Halcrow, 2013).**

# 2.6 Shoreline movement

## 2.6.1 Overview of the evolution of this shoreline

The evolution of the Exmouth BMP frontage is directly related to the evolution of the Exe Estuary. This is well described in the *EEFCERMS* (Atkins/Halcrow, 2013) conceptual model and is repeated here for ease of reference:

*The historic and present day dynamics of the Exe Estuary and surrounding coast is described in detail in SCOPAC (2004). The Exe Estuary basin is considered a long established feature, potentially dating from the late Tertiary period. In the estuary basin, Holocene channels at a level of -50 to -30mAOD exist, and as sea level rose these channels were filled in by fluvial gravel. Subsequent to this (in the Weichselian) the gravels were re-excavated to a depth of 9m. The channels then subsequently infilled with both sand and mud sediments.*

*The formation of the Dawlish Warren and Exmouth spits is considered to have occurred in the early to mid-Holocene period, and were formed by shoreward movement of fluvially or periglacially deposited sand, and longshore drift of these sediments. Subsequent to this the weight of opinion suggests that any offshore reservoir of sand was exhausted or made inaccessible over the last 2-3,000 years, effectively implying the existing outer estuary sediment budget is finite, with new inputs limited cliff erosion and extreme storm events.*

*From the mid to late Holocene, once submergence of the lower Exe valley created the present day estuary, fine-grain sedimentation the estuary basin is considered to have been continuous. The estuary therefore represents a sink for fine sediment, with sand and gravel being deposited temporarily close to the estuary entrance. Inputs come from both fluvial and marine sources, with fluvial sources now limited in comparison to the past.*

*The present day Exe Estuary system that has evolved is a macro-tidal estuary, with current speeds varying between 1-3m/s at the entrance. Penetration into the estuary from offshore waves is limited due to the presence of Dawlish Warren spit and to a lesser extent Exmouth spit. Internally generated waves are both fetch and depth limited, with the head of the estuary experiencing larger waves due to the increase north-south fetch. Extreme water levels in the estuary basin are caused by tidal surges, rather than fluvial flows. However, extreme fluvial flows are important, although not dominant as compared to tidal surges, in the lower reaches of the rivers Exe and Clyst and the inner estuary.*

*Intertidal areas in the estuary basin are composed of mud and sand flats, with both temporary and permanent intertidal habitat (such as saltmarsh and eel grass). Sedimentation in the estuary basin (excluding the flood delta and sub-tidal channels) prior to 1930 was of the order of 40,000$m^3$/yr, however since then this appears to have slowed by an order of magnitude to 4,000$m^3$/yr.*

*The movement of sediment around the outer estuary is complex, with details of recent conceptual understandings presented in Posford Duvivier (1998), SCOPAC (2004), with further details in Halcrow (2008). In essence, it is suggested by Posford Duvivier (1998) and SCOPAC (2004) that there are two distinct linked circulations of bedload sediment transport:*

- *Wave driven net onshore and longshore movements across Pole Sands towards Dawlish Warren. Flood tidal currents combine with waves to introduce sediment into the estuary mouth.*
- *Dominant ebb tidal transport south-eastward from the estuary mouth to accreting sand banks flanking the tidal channel along Exmouth beach. Offshore movement of the sediment is reversed by wave action eventually, pushing the sediment back north-westward towards Pole Sands.*

*These circulations have been set in the context of the understanding gained from Halcrow (2008) and the studies herein, particularly in relation to historic movement of Dawlish Warren and Exmouth beach. These studies have confirmed the long-term trend that Dawlish Warren is rotating anti-clockwise into the estuary, and that the central and proximal sections are eroding, whilst the distal end is accreting. In addition to this, Exmouth beach is found to be eroding overall, with Pole Sands more recently exhibiting a marginal erosional trend. Related to this, Bull Hill Banks is found to be accreting, with the likelihood that the estuary mouth is also accreting (historically addressed by capital and maintenance dredging). Looking at the outer estuary system as a whole, the present day trend appears to be for transport of sediment from the*

*adjacent coast and ebb delta towards the estuary mouth and flood delta, suggesting an overall movement of sediment in-estuary.*

### 2.6.2 Beach profile analysis

Changes in beach profile have only been assessed since 2007, when consistent data for much of the BMP frontage became available through the South West Regional Coastal Monitoring Programme (SWRCMP). The changes observed are best summarised in the overview plots produced by Plymouth Coastal Observatory (PCO) for the SWRCMP; these are provided in Figure 2-4A and Figure 2-4B and show changes in cross-sectional area along a number of beach profiles along the Exmouth BMP frontage between Spring 2007 and Spring 2013.

The SWRCMP data was also used to undertake beach profile analysis as part of the *EEFCERMS* (Atkins/Halcrow, 2013), though that only analysed data between Spring 2007 and Spring 2010 (as that was the data available at the time of that work). The *EEFCERMS* analysis concluded that the Exmouth frontage is experiencing net erosion of beach sediment over time and this informed development of the conceptual model presented in Figure 2-3 above.

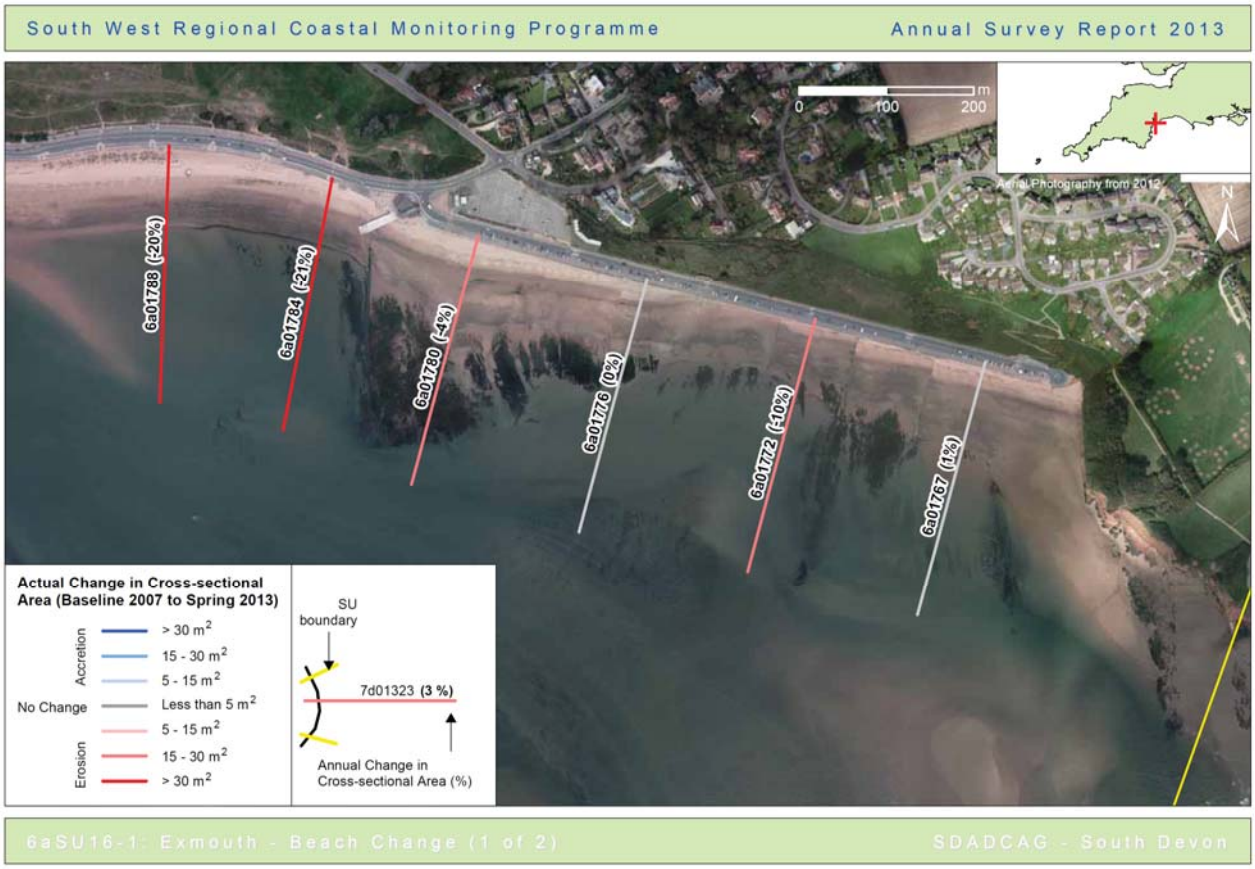


FIGURE 2-4A
**Change in cross-sectional area for the Exmouth BMP frontage (eastern part) (from PCO, 2013).**

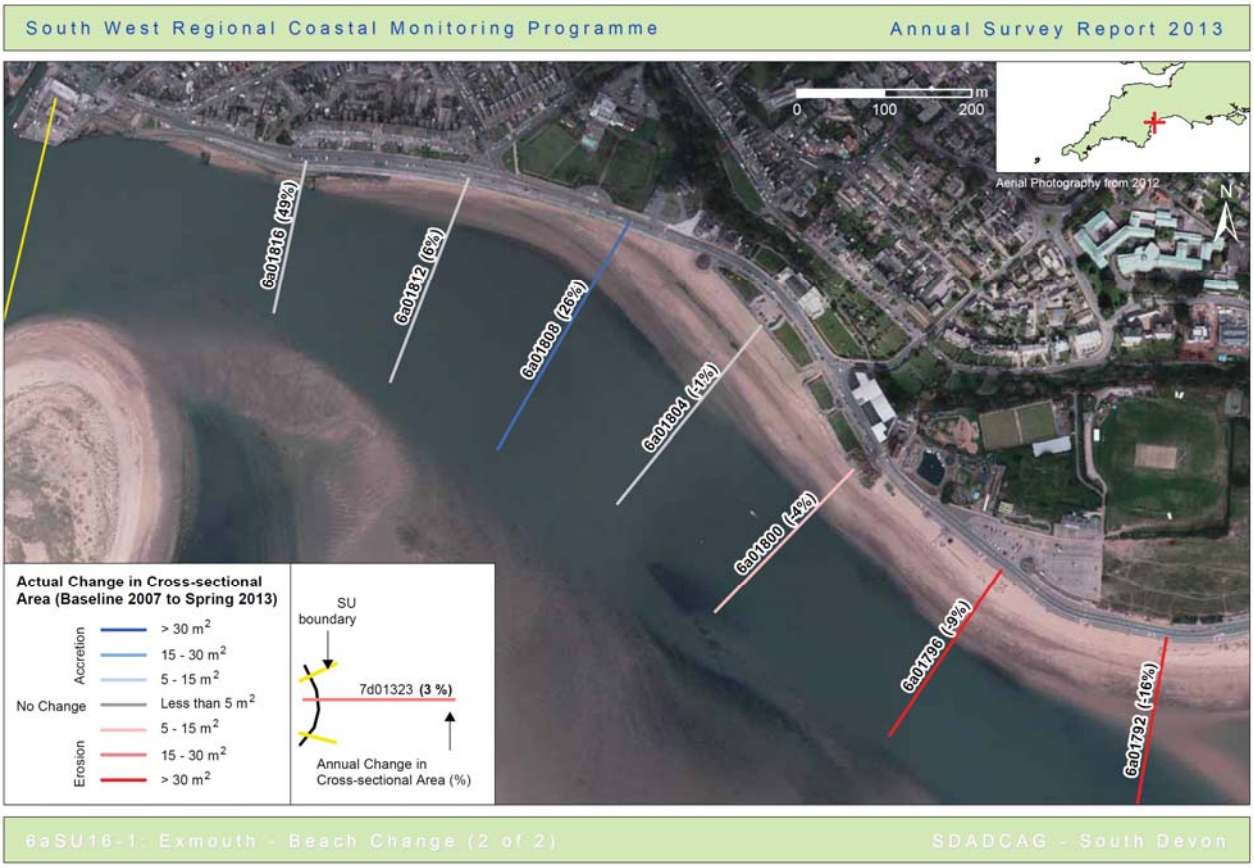


FIGURE 2-4B
**Change in cross-sectional area for the Exmouth BMP frontage (western part) (from PCO, 2013).**

### 2.6.3 Beach profile storm response

In addition to undertaking routine beach profile surveys, PCO also undertake post-storm surveys (refer to Section 4.2.2).

Such post-storm survey data was analysed as part of the *EEFCERMS* (Atkins/Halcrow, 2013) and concluded that the response of Exmouth Beach to storm events appears to be to move sediment in a cross-shore direction, and that in most areas this means sediment moving in an offshore direction. Recovery of the beach following a storm is then a gradual process taking several months. This behaviour appears to occur in response to waves from both south-easterly and southerly directions, although the limited data available for analysis [at the time of the *EEFCERMS* assessment only 2 post-storm surveys for Exmouth were available] means there remains significant uncertainty about this. This uncertainty is only added to by the fact that for both storm events analysed in the *EEFCERMS*, the previous (pre-storm) survey data was captured several months to a year prior to the post-storm survey. This means it is also not possible with any great confidence to determine the effect of the storm compared to other changes over the longer period since the previous surveys.

Following the *EEFCERMS* work, a series of severe storms impacted the south coast of England in the winter of 2013/14, prompting a significant amount of data capture and analysis to understand the impacts of those storms on the beaches of the south coast, and their subsequent recovery. In relation to the Exmouth BMP frontage, this is best summarised in the *Review of South West Coast Beach Response to Wave Conditions During the Winter of 2013-2014* (PCO, 2014a and 2014b). This work identified that the storm on the 5th February 2014 had a return period of about 1:20 (5% APO) based on data captured by the Dawlish wave buoy (refer also to Section 2.1), with a peak wave height of 4.91m. A subsequent storm on 14th February 2014, that caused damage to other parts of the coast, at Exmouth was assessed

as being only about a 1:1 year (100%APO) event (i.e. a typical annual storm) with peak wave height of 4.14m (PCO, 2014a).

In terms of beach volume changes as a result of the winter 2013/14 storms along the BMP frontage, the PCO analysis (PCO, 2014b) determines that about 33,355m$^3$ of sediment was removed from the beach area as a result of the 2013/14 storms. This is greater than the total loss of sediment between 2007 and 2013 for the same area (29,200m$^3$ over that 6 year period). However, by Summer 2014, the volume of sediment on Exmouth frontage had recovered by 24,309m$^3$, meaning within less than 6 months of the storms ending in February 2014, 73% of the sediment 'lost' from the beach during the storms had returned to the Exmouth BMP frontage. However, whilst sediment has returned to Exmouth Beach, the impact of the winter 2013/14 storms was to cause extensive erosion of the sand dunes located with MU2 seawards of Queen's Drive. Visual inspection of these dunes during a site visit by CH2M HILL on 8$^{th}$ December 2014 found them to be in very poor condition still. Although some natural recovery may occur given the apparent return of sediment to the beach system, it is unlikely that these dunes will recover naturally to their pre-winter 2013/14 state without proactive management.

### 2.6.4 Predictions of future shoreline change

The future evolution of the Exmouth BMP frontage is tied to the future evolution of the wider Exe Estuary mouth, and in particular how Dawlish Warren, Pole Sands and Bull Hill Bank evolve as sea level rise. However, based on assumptions aligned to the preferred approach for Dawlish Warren in the adopted *EEFCERMS*, along the Exmouth BMP frontage, given the expectation that existing defences will continue to be present over the next 100 years, it is predicted that (unless beach recharge occurs) there will be a continued reduction in the size of beach fronting the seawalls along this section of coast as a result of coastal squeeze, even with anticipated beach recycling of sediment along the frontage in line with the *EEFCERMS* preferred option (refer to Section 1.7.2). This will gradually increase the risk of the defences failing in the future as a result of either wave overtopping and/or undermining unless coastal defences are bolstered by either beach recharge supported by shoreline control structures and raising of seawall heights, or implementation of alternative hard defences (e.g. rock revetment) if retention of a beach along the frontage becomes unsustainable on technical and/or economic grounds.

## 2.7 Environmental characteristics

This section provides an overview of the environmental setting and identifies key environmental features both within the BMP area and in close proximity to it used to inform environmental assessment of options as part of the *EEFCERMS* (Atkins/Halcrow, 2013).

The section is structured around a number of environmental topics as highlighted in the first column of Table 2-5. These follow the recommended structure contained in the Beach Management Manual (CIRIA, 2010). The second column in Table 2-5 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 report is able to be developed further should the need arise at a future date, e.g. if the preferred option is determined to present a significant scale or impact as to need a statutory Environmental Statement (ES) to accompany the consent applications (refer to Section 1.6).

TABLE 2-5
**A summary of the 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 |

## 2.7.1 Geology and geomorphology

### 2.7.1.1 Geology

The impact of geology on flood risk and erosion is determined by the effects on topography, the permeability of rocks and their resistance to erosion. Permeability, along with other factors such as vegetation cover and topography, will influence the response of an area to a rainfall event. The hardness of the rocks across the Study Area has heavily influenced the evolution and shape of the estuary and continues to exert an influence on topography and rates of erosion.

The BMP area is underlain predominately by sedimentary breccias, siltstones, sandstones and mudstones of transitional Permo-Triassic geological age. Overlying the Permo-Triassic bedrock within the Study Area are a variety of unconsolidated superficial or 'drift' deposits. These deposits are dominated by 'Tidal Flat Deposits' generally consisting of sand and gravels of Quaternary geological age.

In addition to the naturally occurring drift deposits, there are likely to be a number of localised bodies of man-made fill or 'made ground' occurring within the BMP area (of note includes the Imperial Recreation Ground, The Point, Exmouth – a historic post WWII Landfill).

There are four geological designated sites within the BMP area, which support important geomorphological and geological features, as follows:

- The coastline between Orcombe Point and Otter Cove at Straight Point in the Study Area lies partially within the western extent of the Dorset and East Devon World Heritage Site (WHS), administered by the UNESCO World Heritage Committee. This WHS is recognised for its important geological formations from the Triassic, Jurassic and Cretaceous periods, fossils, geomorphology, history of science, ongoing research and aesthetic beauty.

  Natural erosion is a key driver in maintaining the geological interest of this part of the coastline (the 'Jurassic Coast') within the Study Area by exposing rock sequences in the cliff faces and releasing fossils to the beach. Balancing collecting pressure, public access and scientific study is another challenge for management (Environment Agency, 2010).

- Exe Estuary SSSI comprises:
  - Orcombe rocks (also part of the Jurassic WHS and designated as a RIGS), which display an excellent coastal section in the sandstones, siltstones and mudstones of the Permian Exmouth formation. The site is also important for understanding Late Permian

environments, and is also of general geomorphological importance for the study of sedimentation processes; and

- Dawlish Warren comprises a complex double sand spit formation which, although partially modified by man, represents a classic geomorphological landform of national importance. It has been formed by sand. The area also contains key features of geological interest and has been the subject of considerable scientific research.

- Dawlish Cliffs SSSI shows one of the finest continuous exposures of interbedded Aeolian sands (Dawlish Sands) in the country and water-laid, breccia-filled, fluvial channels from the Permian period. This SSSI comprises Langstone Breccias at Langstone Rock and a 20m thick Aeolian sandstone Permian unit at Coryton's Cove.

Figure 2-5 shows the extent of these designations.

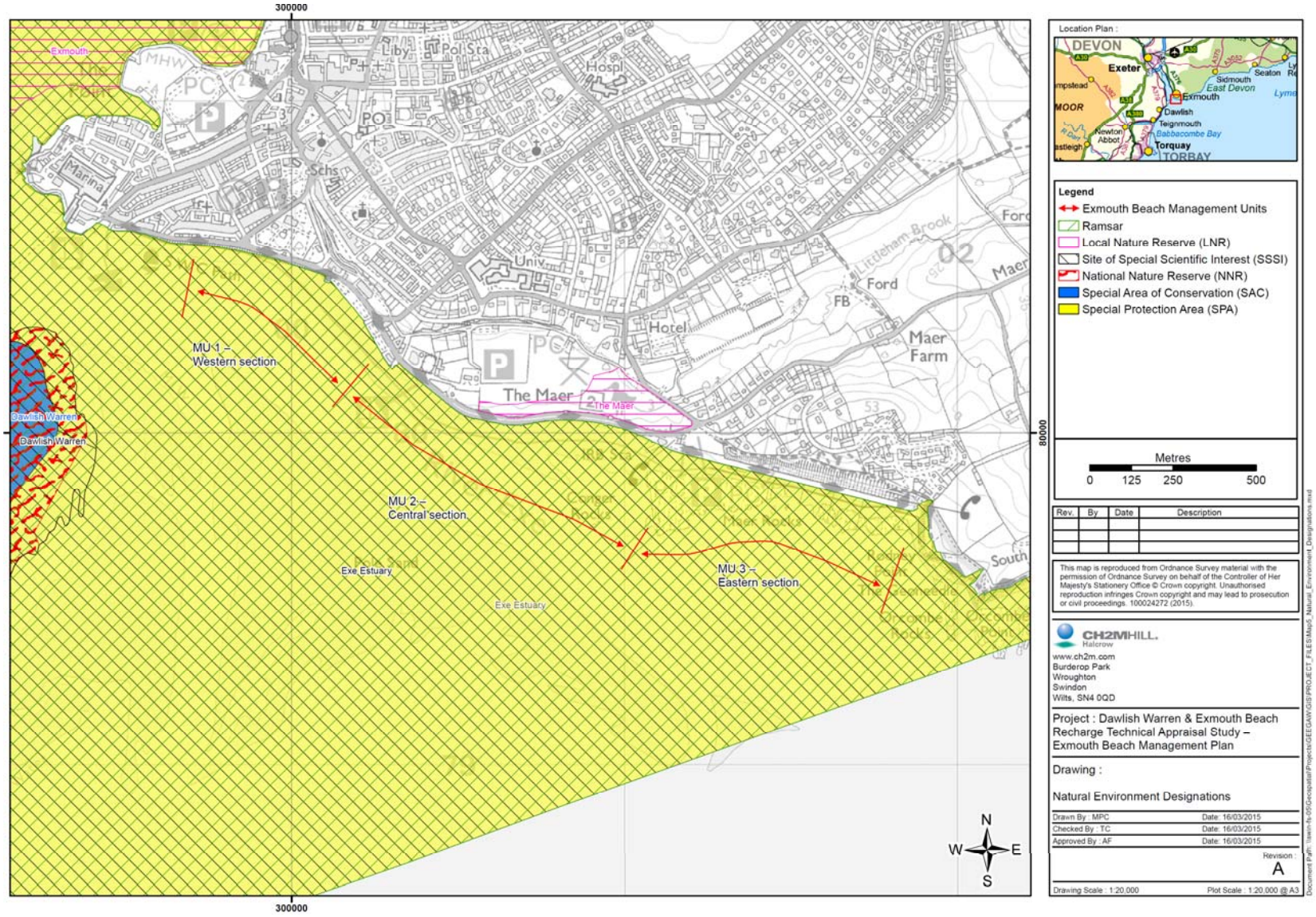


FIGURE 2-5

**Nature conservation designations around the Exe Estuary mouth.**

### 2.7.1.2 Geomorphology

Coastal and fluvial geomorphological processes have shaped the landform of the Study Area and estuary by eroding, transporting and depositing sediment. An understanding of coastal and estuarine processes in and around the Study Area is critical to achieving sustainable flood risk management.

The Exe Estuary is classified as a 'spit enclosed drowned river valley' (Environment Agency, 2010), which has been subjected to marine inundation due to sea level rise at the end of the most recent glaciation (c.12,000 years ago). It comprises a complex semi-natural system of mobile features, including the following main components at the mouth of the estuary:

- Tidal deltas: Pole Sand (ebb) and Bull Hill Bank (flood).
- Dawlish Warren spit - this active sand spit on the western shore of the Exe Estuary (NGR SX 983 788) is 2km long and extends from the western shore of the Exe Estuary approximately three quarters of the distance across its mouth.
- Since at least the 18th century, the western and central parts of the spit have exhibited a net landward rollback into the estuary principally via erosion on the seaward face. The eastern (distal) end is very dynamic, exhibiting cycles of accretion and erosion, with its complete loss recorded between 1940 and 1947. Since c1960s, the distal end has shown net accretion.
- The Exmouth frontage (including the main approach channel, Exmouth Beach, spit, The Maer and Maer Rocks). The resort and historical port and dock of Exmouth is built on Exmouth spit, a small spit which has grown into the mouth of the estuary at NGR SY007 799.
- East of the spit is Exmouth Beach, a relatively steep sandy beach on the east bank of the estuary mouth. The beach extends approximately 3km east from Exmouth docks. Towards the eastern section of the beach is the Maer, a relict dune foreland, now converted to grassland for recreational use. Maer Rocks mark the eastern extremity of the Exmouth frontage, forming a resistant shore platform of Permian sandstone beds.
- The Maer itself was previously an intertidal area, which was reclaimed with the construction of the sea wall, and is now identified as a LNR and CWS and is used as a recreational resource. Near the Maer, there is a very small sand dune system (now largely eroded – refer to Section 1.3.3), with sand dunes at Queen's Drive West and Queen's Drive East. These are a popular amenity for recreation. The dunes are within the Exe Estuary SSSI and Exe Estuary SPA.

The Exe Estuary system is responding to sea level rise and anthropogenic activity, in the form of dredging, reclamation of former intertidal areas, railway construction, weirs, coastal defence works and commercial and recreational activities. Significant areas of intertidal habitats have been lost within the Study Area through development.

The sediment dynamics of the Study Area and the natural processes influencing Dawlish Warren spit and Exmouth beach are controlled by a combination of tidal flows and waves into (e.g. movement of littoral sediment towards the estuary entrance from Lyme Bay) and out of the estuary, together with freshwater flow and storm events (Environment Agency, 2010).

At present, the estuaries' mudflats, saltmarsh, tidal deltas, sandbanks, approach channel and the distal end of Dawlish Warren are all accreting. A combination of south westerly waves and tidal currents, transports sediment in the nearshore region along Dawlish Warren and deposits it at the distal end of the spit. The beach at Dawlish Warren and intertidal areas around Exmouth Docks are eroding. If this trend continues, the amount of sand available to be transported via longshore drift from west to east across the beach will be reduced, and there is little input of new sediment to the system. Dawlish Warren sand spit is a mobile feature, which has been rotating anti-clockwise around the proximal end into the mouth of the estuary, resulting in a net loss of sediment.

Dawlish Warren is closely associated with a series of sandbanks, of which Pole Sand, seaward of the spit, and Bull Hill Bank, landward of the spit, are the most significant. These features combine to provide both

the estuary and the Exmouth frontage with significant protection from wave attack, coastal surges and other coastal processes.

There is a significant exchange of sediment between the spit and the sandbanks, governed largely by the tides at the estuary mouth. To the east of the estuary, the beach at Exmouth also contributes to the complex sediment transport system. Net sediment transport along Exmouth Beach is via longshore drift running east to west.

Although usually fairly stable, the beaches and dunes are sensitive to storm and tidal influences. Indeed, the effect of the winter 2014/2014 storms caused extensive erosion of the dunes, especially at Exmouth (refer to Section 1.3.3).

The future supply of sediment to the Exe Estuary will essentially determine whether or not the estuary system will accrete or erode in the future. Sediment supply from the west has been cut off due to the construction of the railway line along the cliff toe and sediment supply from the eastern cliffs between The Maer and Orcombe Point has been cut off due to land reclamation and seawall construction. A combination of limited sediment supplied from offshore (although this supply has been disputed in the past) and Orcombe Point being the only contemporary source of sediment to the system, means that the Exe Estuary sediment system potentially relies on relict stores of sediment.

The future morphological response of the estuary to sea level rise is likely to be governed by a number of controls including sediment supply, geological inheritance, the rate of sea level rise, human interference, longshore sediment transport, the hydrodynamic flushing capacity of the estuary and the degree of wave exposure.

### 2.7.2 Sediment quality

The only information available regarding sediment quality in the area are a number of grab samples collected and analysed as part of this recharge technical appraisal project. As noted in Section 2.5.1, this sediment grain size analysis is reported in Appendix F and indicates a $D_{50}$ range of sediment grain size as being between 0.24mm and 11mm. Chemical analysis of these samples was also undertaken to determine pH and calcium concentration only; the results of which are also contained in Appendix F.

These samples were taken from the navigation channel and Pole Sands areas only, and not along the Exmouth BMP frontage, so are only an indication of the sediment along the BMP extent. Further sampling and analysis of sediment along Exmouth beach would be needed to provide site specific data.

### 2.7.3 Water quality

The Exe Estuary is a designated shellfish water under the Shellfish Waters Directive, and is an important industry locally, with mussel and pacific oyster beds in particular. Water quality is monitored in relation to this by Cefas and the Environment Agency. This area is shown on Figure 2-6.

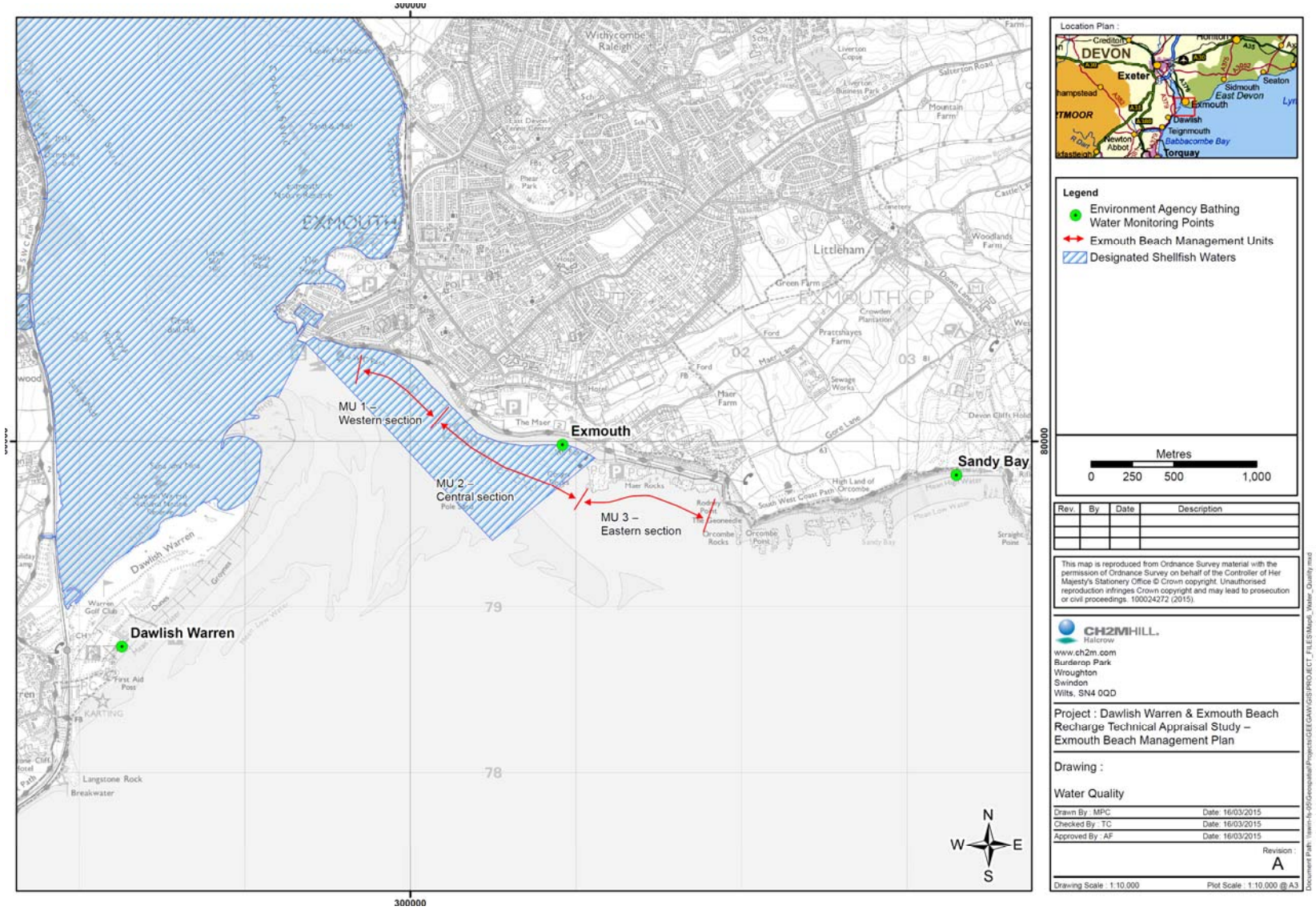


FIGURE 2-6

**Bathing water quality monitoring points and extent of designated shellfish waters within the vicinity of Exmouth Beach**

The Environment Agency also monitors bathing water quality in line with the Bathing Water Directive at several locations within or close to the study area. These locations are also shown on Figure 2-6. The Environment Agency displays the results of their monitoring activities on the *bathing water data explorer* website (http://environment.data.gov.uk/bwq/explorer/index.html) and Table 2-6 summarises the results for each location over the past few years up to 2014.

It should be noted that this table summarises annually the results from weekly samples and are to give an indication only. For example, the 2012 annual result shown for Exmouth states that it failed to minimum standards; further interrogation of the weekly sampling shows that this annual statement is based upon just two separate weeks where a failure to meet minimum standards was recorded, but all other weekly results for 2012 at Exmouth met or exceeded minimum standards.

TABLE 2-6
**Environment Agency Bathing Water Sampling Compliance**

| Location | Annual Compliance Results | | | | |
|---|---|---|---|---|---|
| | 2010 | 2011 | 2012 | 2013 | 2014 |
| Exmouth | Minimum | Higher | Fail | Higher | Higher |
| Sandy Bay | Minimum | Higher | Higher | Higher | Higher |
| Dawlish Warren | Higher | Higher | Higher | Higher | Higher |

## 2.7.4 Ecology

### 2.7.4.1 Designated conservation sites

The Exe Estuary is a complex ecosystem with a transition of habitats from the subtidal to intertidal and supratidal zones. These rich and diverse habitats include mud and sandflats, salt and grazing marshes, intertidal reed beds, seagrass communities, sand dunes and foreshores, all derived through natural coastal processes (Environment Agency, 2010).

The intertidal zone within the Exe Estuary comprises a variety of habitats and substrates and provides valuable feeding resources (e.g. cockles *Cardiidae spp*., lugworms *Arenicola marina* and other invertebrate species) for internationally important numbers of wading birds. The sandbanks and mudflats support communities of invertebrates that are of national significance including the rare polychaete worm (*Ophelia bicornis)*, only found at one other site in Britain, as well as providing flat fish nursery areas. At high tide the mudflats are covered by water and at low tide they are exposed. The sediment that forms the mudflats is carried from the wider catchment by the River Exe and is deposited in the estuary. The mud in the upper estuary is fine silt, but towards the mouth of the estuary the sediment becomes more coarse and sandy. Where the sediment becomes coarser and stones and shells are present, eel grass (*Zostera marina*), mussels (*Mytilus edulis*) and algae are able to attach to it with areas dominated by these species. Eel grasses *Zostera spp* help to stabilise sediment, provide organic matter and shelter, and are a surface for attachment by other species such as small snails. It is an essential habitat for wigeon (*Anas Penelope*) and Brent geese (*Branta bernicla*) which feed on it. The eel grass acts as a nursery for small fish and crustaceans, such as plaice and prawns, who feed on the algae attached to the leaves and shelter from predators. These are prey for a number of bird species including the rare Slavonian grebe (*Podiceps auritus)*.

The main beach habitats present are sand dunes, sand, clay, gravels and wooden groynes along Dawlish Warren Spit and sand, wooden groynes and a limited area of sand dunes along Exmouth Beach. The sand dunes support a high botanical diversity and the Exe Estuary is the only location in Britain for the 'warren crocus' (Environment Agency, 2010). The sand spit at Dawlish Warren provides a sheltered environment for habitats such as saltmarsh, mudflat and eel grass. The spit is also an important feeding and roosting area for wildfowl. JNCC has reported the presence of an expanding population of Annex 2 species petalwort (*Petalophyllum ralfsii)* occurring on two dune slacks along Dawlish Warren Spit. There are also populations of liverwort *Fossombronia incurve* (reported by JNCC).

Exposure to wave action is the most important factor determining the variety and abundance of invertebrates on the beaches. When exposure is high (e.g. at the Exe Estuary mouth and along the coast), few organisms will survive. Sediment size is also of importance in determining the presence of invertebrates and hence the availability of food for feeding birds. Hence the shores and mudflats are more valuable than the sand dominated systems. Furthermore, the abundance and diversity of invertebrates inhabiting sand beaches is limited due to the instability of the substrate, the abrasive nature of the sediment, a high-wave energy environment and the low levels of organic matter present. .

#### 2.7.4.2 Fish ecology

The River Exe and its tributaries support fish populations considered to be of particular conservation importance. Species include sea trout, wild brown trout, rainbow trout, grayling and Atlantic salmon. The salmon migrate through the rivers and streams of the Exe catchment to breed in the upper reaches and are highly sensitive to changes in flow regime. The Environment Agency have a duty to maintain, improve and develop salmon, freshwater fish and eel fisheries. In the past, the illegal exploitation of salmonoids in the Exe has been a concern and poaching activities have had a detrimental effect on the fish stocks. Obstructions in the rivers have also impacted on the fish populations in the catchment. In particular it is known that migrating salmon have difficulties negotiating St James Weir at Exeter during times of low flows. The entire estuary is designated as a sea bass nursery area, which is important to the sustainability of local bass stocks for sea angling. A closed season for boat fishing occurs between 30 April and 1 November (Atkins/Halcrow, 2013).

In addition, the estuary is also a designated shellfish area (refer to Section 2.7.3) and supports a well-established mussel and pacific oyster farming industry.

#### 2.7.4.3 Biodiversity Action Plan (BAP) habitats and species

The government has a commitment “to conserve and enhance the biological diversity within the UK and to contribute to the conservation of global biodiversity through all appropriate mechanisms”. Biodiversity Action Plans (BAPs) have been created at a national and local level to protect and enhance the diversity of flora and fauna. The UK BAP (JNCC website) sets out action plans for priority species and habitats. Local Biodiversity Action Plans (LBAPs) are used to identify the local contributions that can be made to achieving the UK BAP priorities as well as identifying other local biodiversity priorities. LBAPs relevant to the BMP area include:

- *South West Biodiversity Implementation Plan* (South West Regional Biodiversity Partnership, 2004); and
- *Devon Biodiversity and Geodiversity Action Plan* (Devon Biodiversity Partnership, 2005).

The following are listed as UK priority BAP habitats / species and are potentially represented within or in close proximity to the BMP area:

- Coastal sand dunes.
- Coastal saltmarsh.
- Intertidal mudflats.
- Coastal and floodplain grazing marsh.
- Estuaries.
- Seabirds.
- Seacliff and slope.
- Allis shad *Alosa alosa* and Twaite shad *Alosa fallax*: both of conservation concern.
- Sea lamprey *Petromyzon marinus* migrate through the estuary.
- Atlantic salmon *Salmo salar* migrate through the estuary.
- European eel *Anguilla Anguilla*: of conservation concern.

These BAPs were considered when developing the *EEFCERMS* in order to ensure all biodiversity is conserved/enhanced, and not just the most valued sites (refer to Atkins/Halcrow (2013) for further details).

The *South West Biodiversity Implementation Plan* (South West Regional Biodiversity Partnership, 2004), and the *Devon Biodiversity and Geodiversity Action Plan* (Devon Biodiversity Partnership, 2005) are the relevant biodiversity plans for the BMP area.

The following are UK priority BAP habitats and are recorded on Natural England's MAGIC website (http://www.magic.gov.uk/home.htm) and are potentially represented within, or in close proximity to, the BMP area:

- **Maritime cliffs and slopes** – feature located at the eastern end of the BMP extent, extending eastwards from Orcombe Rocks into Sandy Bay.
- **Mudflats** – feature located within the Exe Estuary to the west of the BMP area.
- **Coastal Sand Dunes** – feature located along Dawlish Warren on the opposite side of the mouth of the Exe Estuary from the BMP area.

The Devon Biodiversity and Geodiversity Action Plan (Devon Biodiversity Partnership, 2005) identify a number of specific objectives aligned to the above mentioned UK priority habitats. The most relevant of these objectives are described below:

- **Sea Cliffs and Slopes:**
    - Objective 1 – Maintain and where appropriate improve areas of high nature conservation interest that are currently in good condition for wildlife and/or earth heritage interests.
    - Objective 5 – Ensure the natural processes of erosion and sediment movement continue to operate on all areas of conservation interest, with due regards to essential coastal protection of settlements.
- **Estuaries:**
    - Objective 1 – Protect, maintain and enhance the extent and condition of estuarine habitats in Devon and ensure the protection of species which depend on these habitats, subject to natural change.
    - *NB: In the case of the Exe Estuary, BAP species that are reliant on the habitat within the estuary include Atlantic Salmon and migratory waterfowl and wading birds such as Wigeon, Brent Geese and the Slavonian Grebe.*

## 2.7.5 Fisheries

### 2.7.5.1 Commercial fishing

The study area is within the Devon and Severn Inshore Fisheries and Conservation Authority's (IFCA) district.

The Exe Estuary supports significant fishing activity with ten commercial fishing boats perating out of the Exe. Exmouth supports small fishing fleets with inshore boats and inshore scallop dredgers/beam trawlers. Static gear are set for potting/whelking and cuttle trapping activities. Commercial trawlers also fish for mixed species such as sole, plaice, dab, flounder, turbot, brill, whiting, pollack, ling, conger eel, john dory, ray, gurnard, dogfish, monkfish, red mullet and black bream (Atkins/Halcrow, 2013).

### 2.7.5.2 Recreational fishing

The Exe Estuary attracts recreational fishers fishing , with a range of species available including Salmon at certain times within the Exe Estuary (March to September), for which a rod licence is needed from the Environment Agency.

### 2.7.6 Navigation

The BMP area is located along the north shore of the Exe Estuary navigation channel. This is used to provide access for the commercial fishing fleet that operates out of Exmouth (refer to Section 2.7.5.1). The area is also popular for recreational sailing and power craft who often launch from the beach. Any future beach recharge scheme will also need to consider potential impacts upon these uses BMP area, along with potential impacts on the RNLI lifeboat station and slipway located at the western end of BMP MU 3.

In support of the above uses of the Exe Estuary, the navigation channel is regularly surveyed every 6 months by the Harbour Authority for the Exe Estuary (Exeter City Council) to monitor the need (or otherwise) for dredging of the channel or, more commonly, the moving of navigation markers to reflect changes in the position of Pole Sands at the mouth of the estuary (Exeter City Council website).

### 2.7.7 Landscape setting

The Exmouth BMP area is within (at its eastern end) the East Devon Area of Outstanding Natural Beauty (AONB). This landscape designation is represented on Figure 2-7 showing the spatial extent of the AONB in relation to Exmouth.

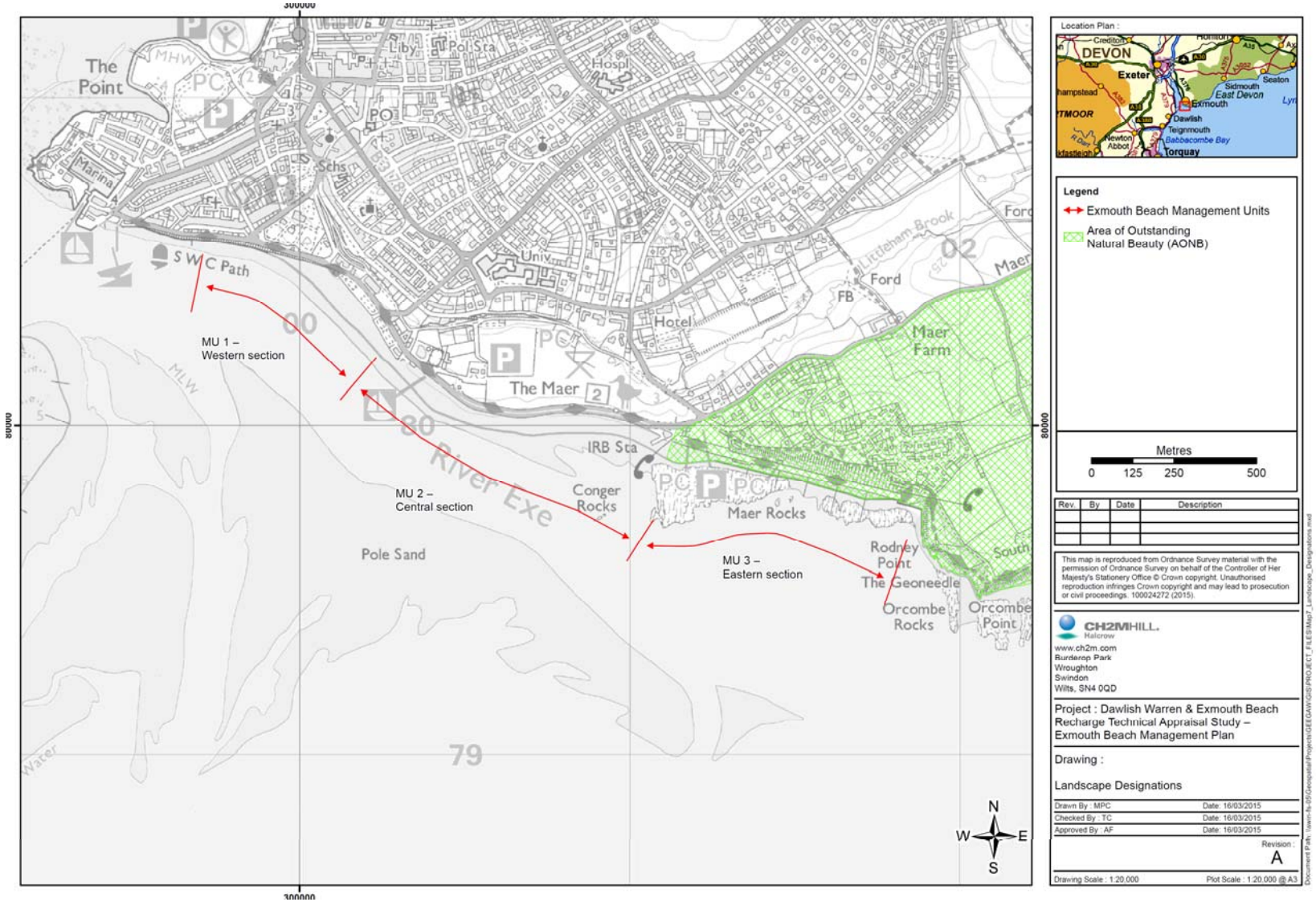


FIGURE 2-7
**Landscape designations**

### 2.7.8 Archaeology and cultural heritage

The Exe Estuary is an area of archaeological and historical significance, with features dating from the early prehistoric to the 20th century (see Figure 2-8). Given its long and varied history, the Exe Estuary contains many sites of archaeological and historical importance. The historic marshland landscape of the estuary is also important and provides evidence of land reclamation over the centuries.

There are no Schedule Monuments within the Study Area. However, there are a number of entries on the National Heritage List for England within 2km of the Study Area, including:

- Devon Historic Environmental Register (HER) Features:
  - WWII Aircraft Obstruction, Dawlish Warren (HER ID# 73288);
  - World War 11 pillbox, Dawlish Warren (HER ID# 55104);and
  - World War 11 pillbox, Langstone Rock (HER ID# 54918).
- Conservation Areas:
  - Dawlish Conservation Area;
  - Exmouth Conservation Area – Louisa Terrace/The Beacon - this area overlooks Exmouth Frontage; and
  - Exmouth Conservation Area – Bicton Street - this area is set back from the seafront.
- Registered Parks and Gardens:
  - Powderham Castle Registered Park and Garden.

There are a number of Listed Buildings within the Study Area, including Grade I and Grade II* designated buildings and structures. The greatest concentrations of Listed Buildings are those within the towns and village surrounding the estuary (notably Exmouth). The density of concentration reflects historic settlement within the area, and is reflected within the extent of the Conservation Areas.

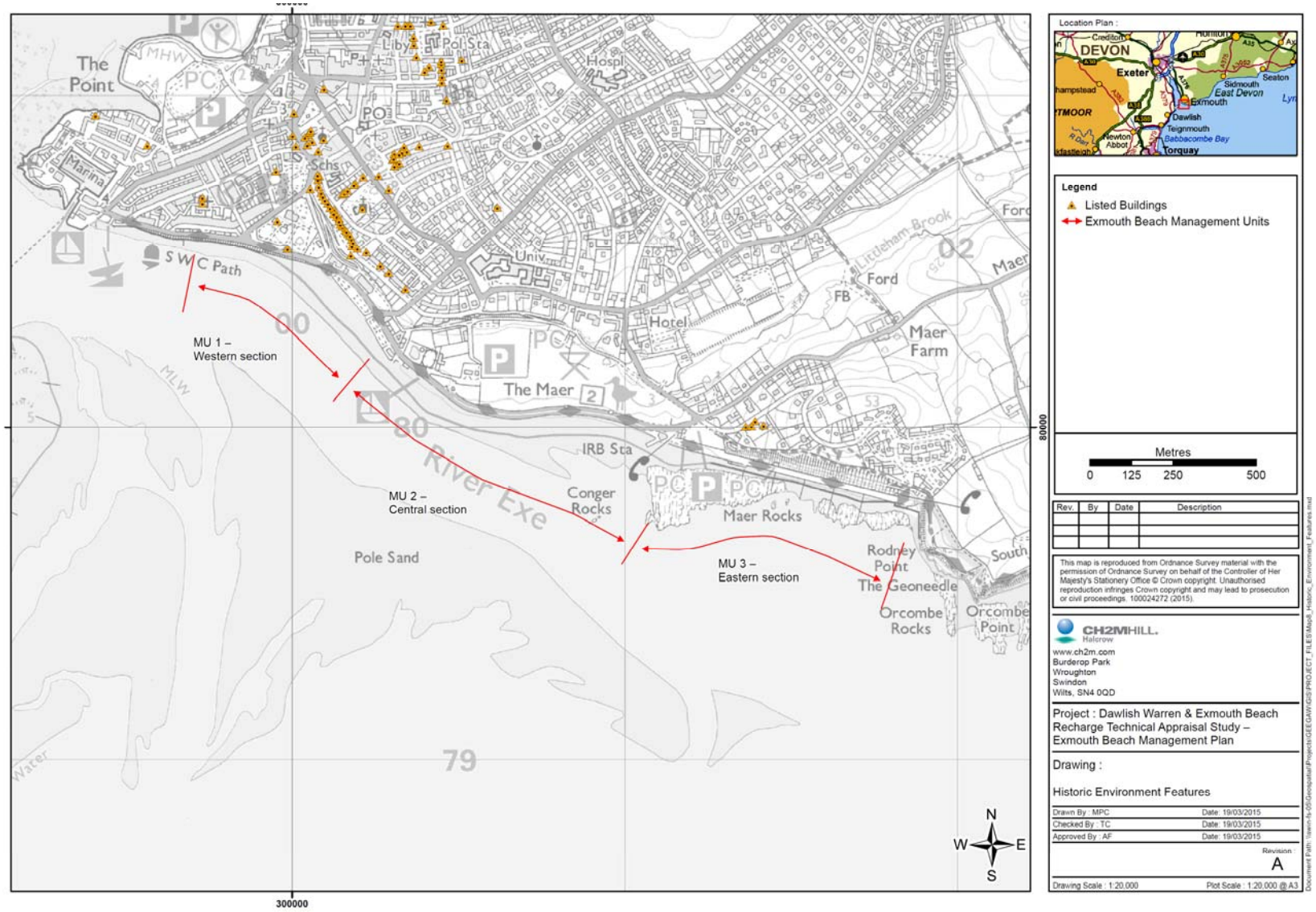


Figure 2-8
**Historic environment features**

### 2.7.9 Air quality

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

### 2.7.10 Noise

No baseline data on existing background noise level has been sourced for this baseline report. 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 present day coastal defences along the Exmouth BMP frontage comprise a number of masonry and concrete seawalls constructed and re-constructed since the 1960s. These serve to provide coastal flood and erosion protection to Exmouth town. The seawalls are supported in this by a number of timber groynes (of unknown construction date) at the eastern end of the BMP frontage (in BMP MU3), as well as flood gates/boards that are installed by EDDC to close 'gaps' in the seawall at access points when flood warnings are issued by the Environment Agency.

Further details about the present defences and their condition along the Exmouth BMP extent are provided in Section 1.3.3, Section 1.3.4, and Appendix A.

No 'as built' drawings of any of the defences along the frontage are thought to exist. Limited information about the defences is provided in Annex B of Appendix A in the form of defence cross-sections derived from trial pit inspections undertaken in January 2014. However, the information provided from this trial pit investigation is poor and does not provide suitable information to assess the likelihood of undermining (refer to Section 3.2.2) and allow trigger levels to be defined (refer to Section 3.2.3).

## 3.2 Standard of protection

### 3.2.1 Overtopping analysis

One of the key performance criteria of sea defences is the overtopping discharge permitted by the structure. Overtopping analysis has been undertaken as part of developing this BMP. This is reported in full in Appendix B. The following summarises the key findings of the analysis.

The Standard of Protection (SoP) for structural damage has been calculated based on a tolerable discharge of 50 l/s/m. The SoP for public safety has been assessed using a tolerable discharge of 0.1 l/s/m in accordance with the EurOtop manual (Environment Agency, 2007). The SoP has been calculated for the present data (year 0) and for years 50 and 100, allowing for climate change and sea level rise. This has been done for four profiles aligned to SWRCMP profile locations (refer to Section 4.2.1). Tables 3-1, 3-2 and 3-3 indicate the SoP against wave overtopping at year 0, year 50 and year 100 for each frontage.

TABLE 3-1
**Empirical relationship overtopping discharge at year 0 (2011) (l/s/m) (refer also to Appendix B)**

| Return Period | SWRCMP Beach Profile Location | | | |
|---|---|---|---|---|
| | 6a01767 (Point 6) | 6a01776 (Point 7) | 6a01792 (Point 8) | 6a01808 (Point 9) |
| 1 | 0.03 | *N/A* | 0.00 | 0.06 |
| 2 | 0.08 | 0.29 | 0.00 | 0.14 |
| 5 | 0.30 | 3.80 | 0.00 | 0.28 |
| 10 | 0.74 | 5.48 | 0.00 | 0.41 |
| 20 | 1.77 | 10.31 | 0.00 | 0.55 |
| 50 | 5.84 | 15.90 | 0.00 | 1.02 |
| 100 | 35.75 | 21.04 | 0.01 | 1.52 |
| 200 | 271.12 | 37.20 | 0.01 | 2.22 |
| 500 | 1396.54 | 104.83 | 0.02 | 2.60 |

TABLE 3-2

**Empirical relationship overtopping discharge at year 50 (2061) (l/s/m) (refer also to Appendix B)**

| Return Period | SWRCMP Beach Profile Location | | | |
|---|---|---|---|---|
| | 6a01767 (Point 6) | 6a01776 (Point 7) | 6a01792 (Point 8) | 6a01808 (Point 9) |
| 1 | 0.44 | 3.54 | 0.00 | 0.16 |
| 2 | 0.86 | 5.67 | 0.00 | 0.33 |
| 5 | 2.46 | 8.92 | 0.00 | 0.65 |
| 10 | 6.01 | 13.41 | 0.00 | 0.96 |
| 20 | 15.19 | 26.32 | 0.01 | 1.29 |
| 50 | 45.80 | 45.71 | 0.01 | 2.39 |
| 100 | 474 | 77.77 | 0.03 | 3.48 |
| 200 | 6427 | 138 | 0.06 | 5.12 |
| 500 | *SWL* | 1268 | 0.08 | 6.22 |

TABLE 3-3

**Empirical relationship overtopping discharge at year 100 (2111) (l/s/m) (refer also to Appendix B)**

| Return Period | SWRCMP Beach Profile Location | | | |
|---|---|---|---|---|
| | 6a01767 (Point 6) | 6a01776 (Point 7) | 6a01792 (Point 8) | 6a01808 (Point 9) |
| 1 | 6.50 | 10.75 | 0.00 | 0.62 |
| 2 | 12.44 | 25.99 | 0.00 | 1.18 |
| 5 | 33.35 | 43.35 | 0.01 | 2.06 |
| 10 | 77.92 | 79.62 | 0.02 | 2.95 |
| 20 | 240.35 | 152 | 0.05 | 3.8 |
| 50 | 1115 | 654 | 0.10 | 6.62 |
| 100 | *SWL* | 3033 | 0.21 | 9.42 |
| 200 | *SWL* | 141827 | 0.39 | 15.40 |
| 500 | *SWL* | *SWL* | 0.50 | 20.92 |

Notes:

| | |
|---|---|
| | = Overtopping discharge within critical limits for pedestrian safety (0.1 l/s/m) |
| | = Overtopping discharge within critical limits for structural damage (50 l/s/m) |
| *SWL* | = still water level above defence crest therefore beyond limits of calculation |
| *N/A* | = still water level below defence toe level therefore beyond limits of calculation |

Sensitivity analysis testing was conducted for a range of parameters, and the following things were concluded from this procedure:

- An increase of 10% to wave height due to an increase in wave storminess does not produce an unexpectedly high increase in the overtopping discharges. All results are within the same order of magnitude with an average increase of 30%.
- Increases in the toe level to a level of +3.2mOD (or about 1.4m drop from the crest of the seawall) caused a reduction in overtopping discharge, with the SoP for structural stability increased from 1 in 5 years to 1 in 10 years by year 100 (2111) for profile 6a01767 where this was tested.

The findings of this overtopping analysis demonstrate that the eastern part of the BMP frontage, represented by profiles 6a01767 and 6a01776 (i.e. BMP MU 3) is most susceptible to wave overtopping with the potential to cause damage to the crest of the seawall and promenade along Queen's Drive as sea levels rise in the future, compared to profile 6a01808 (BMP MU 1) where the seawall is much higher and so less susceptible to large volumes of wave overtopping occurring. Profile 6a01792 (BMP MU2) also shows low susceptibility to wave overtopping of the sand dunes causing adverse impacts along The Maer section. However, given that the winter 2013/14 storms (refer to Section 2.6.3) has reduced the condition and extent of the sand dunes, unless the dunes recover there is an increased likelihood that

the future scenarios for profiles 6a01767 and 6a01776 (i.e. BMP MU3) would also eventually occur along BMP MU2 as well.

The sensitivity of the overtopping discharge rates to the beach level demonstrates the importance of ensuring appropriate trigger levels are in place that will prevent low beach levels from being reached and thus allowing higher volumes of wave overtopping to occur along BMP MU3 and, potentially, BMP MU2 (refer to Section 3.2.3).

### 3.2.2 Undermining/scour risk

Draw down in the level of the beach in front of the seawalls can result in undermining leading to slumping, collapse and failure of the defence. However, as noted in Section 3.1, there are no 'as built' drawings of any of the defences along the frontage and only limited, poor quality information about the defences is provided in Annex B of Appendix A in the form of defence cross-sections derived from trial pit inspections undertaken in January 2014. As such there is insufficient information available to assess the likelihood of undermining of the seawalls along the Exmouth BMP frontage, although this is a primary driver for the expected beach recycling works defined in the *EEFCERMS* preferred option (refer to Section 1.7.2). **It is therefore recommended that the January 2014 trial pit inspection is revisited to provide better quality data on the arrangement of the toe, including toe level and founding material. This information should be used to assess action levels for beach draw down and associated undermining risk.**

### 3.2.3 Trigger levels

Based upon the analysis presented in Sections 3.2.1 and 3.2.2, it is only possible to define 'alarm' and 'crisis' trigger levels based upon the beach crest level against the Exmouth seawall to achieve a certain SoP against wave overtopping. Consideration could also be given to defining trigger levels to reduce the risk of seawall undermining as a result of scour at the toe of the seawalls once the updated trail pit information is obtained (refer to Section 3.2.2).

When beach levels reach a specific elevation or 'trigger level', an action may be taken (refer to Sections 5.3 and 5.4). The guidance within *Toe Structures Management Manual* (Environment Agency, 2012a) recommends estimation of the trigger level consistent with times when the probability of structural failure reaches thresholds that are deemed important. The trigger levels of a beach will often coincide with the point at which beach levels threaten an unacceptable rate of overtopping or probability of stability failure. Multiple trigger levels can be adopted for a beach which will reflect different risk levels or points at which action is required.

For this BMP, two trigger levels are adopted which will (a) introduce increased monitoring of at risk areas, and (b) initiate works to prevent undermining of the seawall and/or restore the standard of protection against overtopping.

The lack of specific data regarding 'as built' details for the various seawall sections along the Exmouth BMP frontage prevents the accurate determination of structural failure. Also, due to the relatively small duration of beach profile monitoring, it is not possible to use this record to project the trigger levels for future management. As such, consideration of overtopping rates was used to generate a more general threshold to ensure that suitable management of the beach and defences is in place.

It is assumed that the target standard of protection for this frontage is between 1 in 100 years to 1 in 300 years. As BMP MU3 is the main area of the BMP frontage at risk of wave overtopping leading to SoP failure, trigger levels are defined only for this part of the Exmouth frontage. The 'alarm' trigger level for BMP MU3 was calculated by determining the beach level at the toe of the defence that would limit overtopping discharge rates to 50 l/m/s for each frontage during 1 in 200 year extreme events. The 'crisis' trigger level was calculated by determining the beach level at the toe of the defence that would limit overtopping discharge rates to 50 l/m/s for each frontage during 1 in 100 year extreme event conditions. This will ensure that the 1 in 100 year Standard of Protection is retained, protecting the assets within Exmouth. The trigger levels for BMP MU3 are therefore:

- **Action Level:**
    - If drop from top of seawall (crest level +4.6mOD) is greater than 1.5m, then instigate more regular monitoring (refer to Section 5.3) as there is an increased risk wave overtopping during storms could exceed the 1 in 200 year SoP threshold.
- **Crisis Level:**
    - If drop from top of seawall (crest level +4.6mOD) is greater than 2.0m, then consider implementing beach recycling or other measures (refer to Section 5.4) as there is an increased risk wave overtopping during storms could exceed the 1 in 100 year SoP threshold.

# 4 Monitoring Regime

The following describes the monitoring regime that is required to inform future management decisions at Exmouth.

## 4.1 Monitoring programme

Table 4-1 provides an outline programme for implementing the monitoring regime, identifying key tasks and estimated timing of each task. This outline programme covers the next five years, in line with the review period for this BMP. Reference should be made to the rest of this section for more detail about the nature of the monitoring shown in Table 4-1.

TABLE 4-1
**Outline monitoring programme**

| TASK | 2015 | | | | 2016 | | | | 2017 | | | | 2018 | | | | 2019 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 |
| Ongoing beach profile, LiDAR, bathymetry and aerial photography monitoring by PCO. | | | | | | | | | | | | | | | | | | | | |
| Establish regular beach profile surveying of additional profiles along frontage (refer to Figure 4-1) | | | | | | | | | | | | | | | | | | | | |
| Add profile ID and beach level markers along the study area to aid visual inspections | | | | | | | | | | | | | | | | | | | | |
| Provide training to local staff to aid call-out of post-storm surveys | | | | | | | | | | | | | | | | | | | | |
| Undertake visual walkover inspections of structures, including 'dip' measurements at points along the frontage to measure distance of drop from seaward edge of seawall crest to beach. | | | | | | | | | | | | | | | | | | | | |
| Undertake full structural inspection of coastal defences | | | | | | | | | | | | | | | | | | | | |
| Record storm event details to support post-storm surveys | | | | | | | | | | | | | | | | | | | | |
| Review all data annually with particular focus on trigger levels | | | | | | | | | | | | | | | | | | | | |

# 4.2 Beach monitoring

## 4.2.1 Routine beach profile survey

Topographic beach profile surveys are carried out by the PCO every spring and autumn at pre-defined locations along the BMP frontages (see Figure 4-1). **Monitoring of beach profiles every spring and autumn by PCO will continue**. Data is available through the PCO website (www.channelcoast.org) from 2007 onwards (when PCO was established).

Table 4-2 provides a summary of the beach profile locations, including origin co-ordinates and dates of first and most recent surveys. It also highlights which profiles are surveyed twice per year as part of the South West Regional Coastal Monitoring Programme, and which of those are also used to capture additional post-storm survey profiles. **It is recommended that the last 3 digits of at least some, if not all, of the Profile IDs listed in Table 4-2 be marked upon the seawall at Exmouth** to allow ease of identification during future walkover inspections of the area.

In order to improve understanding of sediment movements along the BMP frontage and thus provide robust evidence for when and where beach recycling should occur in line with the *EEFCERMS* preferred option (refer to Section 1.7.2), it is recommended that all profiles listed in Table 4-2 be surveyed at least twice per year as well as post-storm surveys (refer to Section 4.2.2). **The frequency of surveys along these profiles should be increased as part of detailed monitoring along the Exmouth frontage and of the nearshore area (refer to Section 4.2.5) to monitor the impacts of the proposed Dawlish Warren Beach Recharge Scheme. This more extensive monitoring should commence prior to that scheme progressing to ensure adequate baseline data is captured (refer also to Section 1.4.4).**

Table 4-2

**PCO beach profile survey locations within the BMP area at Exmouth (NB: those highlighted in yellow are surveyed bi-annually; those not highlighted are surveyed every few years; those in bold are also surveyed as post-storm profiles).**

| Profile ID | Origin Easting | Origin Northing | Date of first survey | Date of most recent survey |
|---|---|---|---|---|
| 6a01765 | 301889 | 79825 | 20/04/2007 | 27/08/2014 |
| 6a01766 | 301843 | 79848 | 20/04/2007 | 27/08/2014 |
| **6a01767** | **301795.96** | **79864.01** | **20/04/2007** | **24/11/2014** |
| 6a01768 | 301748.01 | 79880 | 20/04/2007 | 27/08/2014 |
| 6a01769 | 301710.02 | 79892 | 20/04/2007 | 27/08/2014 |
| 6a01770 | 301672.99 | 79904 | 20/04/2007 | 27/08/2014 |
| 6a01771 | 301640.98 | 79914.01 | 20/04/2007 | 27/08/2014 |
| 6a01772 | 301604.03 | 79922.99 | 20/04/2007 | 24/11/2014 |
| 6a01773 | 301555.98 | 79935.01 | 20/04/2007 | 27/08/2014 |
| 6a01774 | 301507.06 | 79942.99 | 20/04/2007 | 27/08/2014 |
| 6a01775 | 301455.97 | 79944.01 | 20/04/2007 | 27/08/2014 |
| **6a01776** | **301404.94** | **79946.02** | **20/04/2007** | **24/11/2014** |
| 6a01777 | 301354.98 | 79953.01 | 20/04/2007 | 27/08/2014 |
| 6a01778 | 301298.02 | 79930.99 | 20/04/2007 | 27/08/2014 |
| 6a01779 | 301248.97 | 79943.01 | 20/04/2007 | 27/08/2014 |
| 6a01780 | 301201 | 79956 | 20/04/2007 | 24/11/2014 |
| 6a01781 | 301164.98 | 79965 | 20/04/2007 | 27/08/2014 |
| 6a01782 | 301145.99 | 80067 | 20/04/2007 | 27/08/2014 |
| 6a01783 | 301097 | 80084 | 20/04/2007 | 27/08/2014 |
| **6a01784** | **301048.06** | **80099.99** | **20/04/2007** | **24/11/2014** |

| Profile ID | Origin Easting | Origin Northing | Date of first survey | Date of most recent survey |
|---|---|---|---|---|
| 6a01785 | 300998.94 | 80117.01 | 20/04/2007 | 27/08/2014 |
| 6a01786 | 300948.92 | 80134.01 | 20/04/2007 | 27/08/2014 |
| 6a01787 | 300897.02 | 80140 | 20/04/2007 | 27/08/2014 |
| 6a01788 | 300845.97 | 80142 | 20/04/2007 | 24/11/2014 |
| 6a01789 | 300796.94 | 80145 | 20/04/2007 | 27/08/2014 |
| 6a01790 | 300745.99 | 80147 | 20/04/2007 | 27/08/2014 |
| 6a01791 | 300700.02 | 80146 | 20/04/2007 | 27/08/2014 |
| **6a01792** | **300660.06** | **80144.99** | **20/04/2007** | **24/11/2014** |
| 6a01793 | 300617.93 | 80143.02 | 20/04/2007 | 27/08/2014 |
| 6a01794 | 300576.02 | 80141.99 | 20/04/2007 | 27/08/2014 |
| 6a01795 | 300505 | 80099 | 20/04/2007 | 27/08/2014 |
| 6a01796 | 300463 | 80127 | 20/04/2007 | 24/11/2014 |
| 6a01797 | 300421.98 | 80155.01 | 20/04/2007 | 27/08/2014 |
| 6a01798 | 300380.01 | 80183.99 | 20/04/2007 | 27/08/2014 |
| 6a01799 | 300346.01 | 80220.99 | 20/04/2007 | 27/08/2014 |
| **6a01800** | **300317.01** | **80260.99** | **20/04/2007** | **24/11/2014** |
| 6a01801 | 300288.99 | 80301.01 | 20/04/2007 | 27/08/2014 |
| 6a01802 | 300261 | 80342 | 20/04/2007 | 27/08/2014 |
| 6a01803 | 300233.01 | 80381.99 | 20/04/2007 | 27/08/2014 |
| 6a01804 | 300200.02 | 80417.98 | 20/04/2007 | 24/11/2014 |
| 6a01805 | 300158.99 | 80445 | 20/04/2007 | 27/08/2014 |
| 6a01806 | 300113.99 | 80467.01 | 20/04/2007 | 27/08/2014 |
| 6a01807 | 300069 | 80488 | 20/04/2007 | 27/08/2014 |
| **6a01808** | **300024.02** | **80506.99** | **20/04/2007** | **24/11/2014** |
| 6a01809 | 299980.02 | 80525.99 | 03/05/1998 | 27/08/2014 |
| 6a01810 | 299935.01 | 80543 | 03/05/1998 | 27/08/2014 |
| 6a01811 | 299890.99 | 80559 | 03/05/1998 | 27/08/2014 |
| 6a01812 | 299846.01 | 80572 | 03/05/1998 | 24/11/2014 |
| 6a01813 | 299801.01 | 80580 | 03/05/1998 | 27/08/2014 |
| 6a01814 | 299754.01 | 80587 | 03/05/1998 | 27/08/2014 |
| 6a01815 | 299705.99 | 80591 | 03/05/1998 | 27/08/2014 |
| **6a01816** | **299657.99** | **80593** | **03/05/1998** | **24/11/2014** |
| 6a01817 | 299611.46 | 80600.92 | 03/05/1998 | 27/08/2014 |
| 6a01818 | 299564 | 80611 | 03/05/1998 | 24/11/2014 |
| 6a01819 | 299515 | 80620 | 03/05/1998 | 27/08/2014 |
| 6a01820 | 299478.01 | 80637 | 03/05/1998 | 27/08/2014 |
| 6a01821 | 299418 | 80655 | 03/05/1998 | 27/08/2014 |

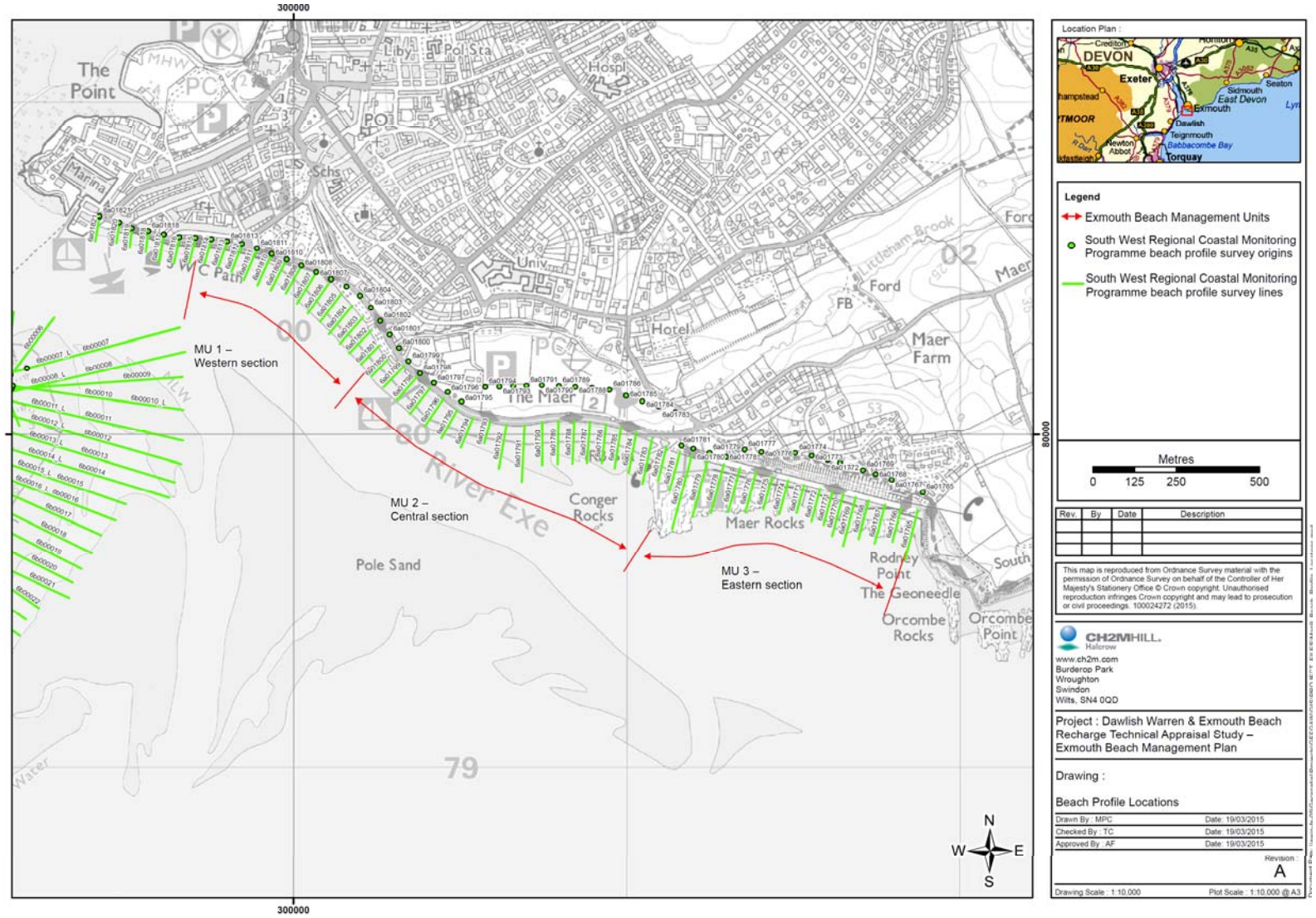


FIGURE 4-1
**PCO beach profile survey locations**

### 4.2.2 Post-storm beach profile survey

In addition to undertaking routine beach profile surveys, PCO also undertake post-storm surveys (see Table 4-2). To date seven post-storm surveys have been carried out on:

- 22nd January 2009
- 20th October 2009
- 27th October 2011
- 26th April 2012
- 1st May 2012
- 18th October 2012
- 7th February 2014.

In order to capture post-storm surveys in the future, **a number of local authority staff who are regularly on-site should be encouraged to report to a key contact in East Devon District Council and/or the Environment Agency as to when a storm event has occurred and resulted in notable change in the beach levels against the seawall and groynes** (refer also to Section 3.2.3). The key contact in East Devon District Council and/or the Environment Agency can then call-out post-storm surveys via PCO. **To support this, some basic training should be provided to the staff who are regularly on-site so they know what to look for**. This could be based upon the Environment Agency's *Condition Assessment Manual* (Environment Agency, 2012) or key beach crest levels marked upon the seawall (refer also to Section 4.2.7). **The arrangements for this, once confirmed, should be captured in a formal communication document so that the role can be communicated to others in the future**.

Once a greater amount of post-storm survey data is gathered, it will be possible to review data and determine if the post-storm profiles surveyed by PCO are the correct ones to be surveying in these circumstances (i.e. are the post-storm profiles representative of storm driven changes in the beaches?). In addition, a greater amount of post-storm survey data may enable **pre-storm profiles to occur if (a) sufficient understanding of the conditions of most concern can be developed through continued capture and review of post-storm surveys in the coming years (refer also to Section 4.5.2), and (b) opportunity arises and/or funding is available.** This is not a key requirement of the monitoring regime but would provide useful additional understanding of the beach behaviour in storm events to inform future management decisions.

### 4.2.3 Master profile survey

There is uncertainty about the precise volume of sediment along the beaches of the BMP frontage. This uncertainty is a result of a lack of understanding of where the sub-strata on which the beach sits, is located beneath the beach.

To address this uncertainty **a survey of underlying bed level could be undertaken if the opportunity arises and/or funding is available**. This data, 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. 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.

### 4.2.4 Beach recycling logs

No beach recycling works occur along the beach frontage at present. However, this I expected to occur at some point in the future (see Section 1.7.2 and Section 5.2.2). Should beach recycling works occur in the future, then **beach recycling logs are to be maintained** by those undertaking the works, with the records then being passed to East Devon District Council, PCO and The Crown Estate. This information will allow future analysis of beach volume changes to more accurately account for the effects of beach recycling work and will enable the underlying natural beach movements to be identified.

To support this, a template beach recycling log to be used is provided in Appendix G. It is to be completed in a simple manner, by tallying the number of truck or dumper loads (of known capacity) transported along the beach during a recycling event. **This could be supported by completing a pre- and post-beach recycling survey for the first one or two beach recycling campaigns to provide actual data against which the recycling logs can be validated.**

This beach recycling log could also be used to capture information about where sand sediment is placed along the beach when it is cleared by EDDC (refer to Sections 5.2 to 5.4).

### 4.2.5 Bathymetric survey

Bathymetric surveys are to continue once every 5 years, in line with the schedule determined by PCO. The next bathymetric survey for the Exmouth area is understood to be programmed to occur in 2019/2020.

In addition to the PCO programme, the navigation channel is regularly surveyed every 6 months by the Harbour Authority for the Exe Estuary (Exeter City Council) to monitor the need (or otherwise) for dredging of the channel or, more commonly, the moving of navigation markers to reflect changes in the position of Pole Sands at the mouth of the estuary. **The information collected by the harbour authority should be reviewed alongside bathymetry and beach profiles survey data collected by PCO to further develop understanding of the sediment transport processes around the mouth of the Exe Estuary as part of future studies.**

**The frequency bathymetric surveys should also be considered in the design of detailed monitoring of the nearshore area to monitor the impacts of the proposed Dawlish Warren Beach Recharge Scheme (refer also to Section 1.4.4 and Section 4.2.1).**

### 4.2.6 Sediment sampling

No sediment sampling is proposed for Exmouth Beach over the period covered by this BMP.

### 4.2.7 Walkover survey

**Visual walkover inspections should be undertaken by East Devon District Council and to monitor beach crest level against the seawall and groynes at Exmouth.**

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 the beach level against the seawall and rock revetment is required to allow use of the trigger levels identified in Section 3.2.3. **To aid the visual inspection, markers defining the beach level in relation to the beach crest level trigger levels could be marked on the seawalls at Exmouth.**

**These visual walkover inspections should also measure 'dip levels' along the frontage (i.e. distance drop from the seaward edge of the seawall to the beach** to capture useful information about the variation in beach level against the seawall in the periods between regular beach profile surveys (refer also to Section 4.2.1). These dip levels will also provide for assessment against trigger levels defined in Section 3.2.3.

### 4.2.8 Aerial photography and LiDAR

Aerial photography and LiDAR surveys are to continue to be flown every one to three years by PCO. This data is available through the PCO website (www.channelcoast.org) for the years 2006, 2009 and 2012 for aerial photography; and years 2007, 2009 (partial), 2010, 2011 (partial), 2012 (partial) and 2014 for LiDAR.

Continuation of these aerial photography and LiDAR surveys, combined with regular monitoring of beach profiles (refer to Section 4.2.1), will inform future derivation of long-term trends of beach volume and recession rates.

# 4.3 Structure monitoring

## 4.3.1 Visual inspection

There are a number of defence assets located along the BMP frontage under the responsibility of EDDC. Appendix A notes the condition of these defences is good to fair with minor maintenance work required to some parts of seawalls and timber groynes within the next two years (refer to Section 5.2.1). **To ensure these assets remain in such condition, ongoing maintenance is required and this will be informed by regular re-inspection of the defences in a similar way to that reported in Appendix A at least once every two years, although annually would be preferable if budgets allow.** These inspections should occur during the spring of each year to allow identification of 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 various structures should be, where possible, undertaken in combination with the visual walkover inspection of the beach as described in Section 4.2.7, particularly following storm events. Each visual inspection should be recorded in a consistent way. To aid this, a template is provided in Appendix H.

The following items should be checked as part of these inspections:

- Visual checking of the beach level in front of the seawalls at Exmouth to ensure that the trigger levels defined in Section 3.2.3 are not reached (refer also to Section 4.2.7).
- Visual checking of access ramps, steps, hand rails etc. to ensure that these are in a safe condition of public use. This should be carried out in accordance with the Environment Agency's public safety risk assessment operational instruction. Refer also to Section 5.2.1.
- Visual identification and checking of any defects (e.g. cracks in the seawall; timber groyne planking etc) and overall defence condition in accordance with the *Condition Assessment Manual* (Environment Agency, 2012b). Refer also to Appendix A as a baseline.

## 4.3.2 Detailed inspection

In addition to the annual and post-storm visual inspections described in Section 4.3.1, **full structural inspections of the Exmouth coastal defences 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, the template provided in Appendix H should be used.

These inspections should also 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.

# 4.4 Environmental monitoring

The area covered by this BMP is within the vicinity of a number of environmental designations, including international and European nature conservation features, designated bathing waters, designated shellfish waters and local landscape designations (refer to Section 2.7). Future beach recycling and/or beach recharge along the Exmouth BMP frontage (refer to Sections 5.2 to 5.4) has the potential to impact upon the bathing water and shellfish water designations and so detailed investigation of the physical and chemical characteristics of the any proposed beach recharge source will be needed before any sediment is placed at Exmouth (this is not an issue if only recycling of sediment along the Exmouth BMP frontage occurs).

**If beach recycling or beach recharge occurs in the future, there will be a need to undertake regular water quality monitoring to assess the impacts (if any) of moving/placing material along the shoreline.** Bathing water quality monitoring is undertaken by the Environment Agency at several locations along the BMP area (refer to Section 2.7.3). This data is considered sufficient to provide a robust baseline for future Water Framework Directive (WFD) assessment that would be needed as part of any potential

future beach recycling or beach recharge that may occur. Post-implementation monitoring could be delivered to ensure the WFD objectives are not compromised by any future works along the frontage.

There are many historic environment features in the area around BMP area (see Figure 2-8 above) and **visual inspections should seek to identify any impacts on these features as a result of beach works (or indeed if 'new' features are uncovered by storm events)**. In the event of impacts or new features being identified, then the Devon Historic Environment Service should be contacted (refer to Appendix C for contact details).

# 4.5 Physical conditions

## 4.5.1 Sea conditions

Wave climate is monitored by a wave buoy located approximately at the -10mCD contour offshore of Dawlish Warren approximately 3.5km south of Exmouth Beach (refer to Section 2.1.1). This wave buoy was installed and is maintained by PCO and recorded data is available through the PCO website (www.channelcoast.org). There is currently only a short-period of data available (data has only been recorded since 7th December 2010). The continuation of data capture by this wave buoy is vital to improving the amount of information available for future assessment of typical and extreme wave climate in the area.

Tide level data is recorded by the Environment Agency at Exmouth.

## 4.5.2 Storm events

The movement of material along the BMP frontage, and the risk of beach lowering leading to increased wave overtopping and/or undermining of the seawall, is significantly increased during storms as a result of increased wave action, particularly when storms waves combine with high tide levels. 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 4.2.2).

Data from the PCO wave buoy at Dawlish and Exmouth tide gauge operated by the Environment Agency (refer to Section 4.5.1) should be used for obtaining details of the wave and water level conditions at the time of the storm event.

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 (www.ndbc.noaa.gov/) and the CEFAS Wavenet (www.cefas.co.uk/data/wavenet.aspx) websites. These websites provide data for a number of locations between the Atlantic and the Bristol Channel that are relevant to the BMP frontage, 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.

**To aid future understanding, a local wind gauge located along the promenade at Exmouth should also be installed to record wind speed and direction as both can have a significant impact on the effect of storm events on the beach response.**

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), any pre/post-storm surveys, and effects/impacts of the event.

# 4.6 Warning and emergency procedures

## 4.6.1 Flood warning and response procedures

Flood warnings and responses are co-ordinated by the Environment Agency's Flood Incident Management Duty Officer based in Exeter. The Duty Officer procedures are available through the Environment Agency's South West Incident Management (SWIM) website (www.imflooding.co.uk) – note this is a secure site for approved Environment Agency users only and all duty officers have access to the SWIM website. Up-to-date hard copies of the procedures are held in the Environment Agency Area Incident Room in Exeter.

### 4.6.2 Pollution incidents

Pollution incidents can occur at varying scales. Minor pollution such as litter and small debris are typically dealt with by EDDC.

Larger pollution incidents are dealt with by a range of organisations including EDDC, Devon County Council and the Environment Agency. The responses to large pollution incidents are guided the *Devon County Council Coastal Pollution Plan* (June, 2008).

## 4.7 Data

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 beaches and coastal defence assets along the BMP frontages for coastal flood and erosion risk management purposes.

Following each scheduled twice-yearly beach profile survey, the information collected is uploaded for storage and analysis to a database system that operated by the South West Regional Coastal Monitoring Programme at PCO. Additional survey data that is to be collected as per the requirements set out in this BMP, should be collected, stored and analysed in accordance with PCO quality standards and be compatible with PCO's database system (if PCO are not used to undertake the additional survey work).

Additional monitoring data, obtained from sources such as the post-storm visual walkover inspections (with associated storm event data – see Section 4.5.2), beach recycling logs (see Section 4.2.4), or defence inspection reports (see Section 4.3) should also be stored in the same database. The database should include any photographs taken during each survey.

This information should be used in assessing the need/potential for future beach recycling/recharge, as well as compiling future annual beach monitoring reports produced by PCO and for use in future studies along the BMP frontages.

In addition, **each year a review of all survey data should be carried out with particular focus on trigger levels defined in Section 3.2.3 and associated coastal flood and erosion risks**.

# 5 Maintenance Regime

The following describes the maintenance regime that is necessary to ensure that the beach and defences at Exmouth continue to provide adequate coastal flood and erosion risk management of the area in the immediate future.

## 5.1 Maintenance programme

Table 5-1 provides an outline programme of beach maintenance works that shows the key activities to be carried out over the next five years until the next BMP review. Reference should be made to the rest of this section for more detail about the nature of the works shown in Table 5-1.

TABLE 5-1
**Outline programme for implementing beach management works over the next 5 years**

| | 2015 | | | | 2016 | | | | 2017 | | | | 2018 | | | | 2019 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TASK | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 |
| Subject to consultation with key stakeholders, undertake beach recycling of sediment from BMP MU2 (the now degraded sand dunes) to BMP MU3 supported by intensive | | | | | | | | | | | | | | | | | | | | |
| Undertake regular clearing of sand from Exmouth promenade and place sediment back on beach. | | | | | | | | | | | | | | | | | | | | |
| Coastal defence assets maintenance (as required), ensuring any defects and/or repairs are recorded consistently | | | | | | | | | | | | | | | | | | | | |
| Develop potential future funding sources (non-FDGiA) should they be needed | | | | | | | | | | | | | | | | | | | | |
| Undertake actions to address public safety issues identified in this BMP and by future visual inspections | | | | | | | | | | | | | | | | | | | | |
| Undertake a review and update of the beach management plan, supported by detailed future studies for the long-term strategic management of the BMP area. | | | | | | | | | | | | | | | | | | | | |

# 5.2 Ongoing works

## 5.2.1 Structure maintenance

Routine maintenance works to the seawalls and timber groynes at Exmouth will be guided by ongoing inspection (refer to Section 4.3). **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 I.

**In respect of coastal defence maintenance requirements to the seawalls and timber groynes along the Exmouth frontage, Table 10 of Appendix A indicates the defects that should be addressed in the immediate future.** These ongoing maintenance works will help to ensure that the coastal defences achieve their expected residual life and so delay the timing of future replacement of structures.

**In respect of public safety issues along the BMP frontages, the following issues need to be addressed in the immediate future (refer also to Appendix A):**

- Provide permanent replacement for temporary access steps at points along Asset numbers 168679 and 113FAS3351002C02 (refer to Table 10 in Appendix A).
- Remove exposed piles from 'groyne 7' adjacent Lifeboat slipway to improve safety for beach users, monitor exposed piles as beach levels change.

## 5.2.2 Beach recycling

The *EEFCERMS* (Atkins/Halcrow, 2013) anticipates beach recycling will be required from about 2020 onwards, with approximately 6,000$m^3$ of beach sediment being recycled along the frontage annually. The source and receptor areas for beach recycling will be guided by ongoing monitoring as set out in Section 4 of this BMP.

However, there is opportunity to implement beach recycling sooner than 2020 from the area in BMP MU2 where the sand dunes have been significantly depleted and are not expected to recover naturally (refer to Section 2.6.3). As such, **consideration should be given in the immediate future to moving sediment from the now depleted sand dunes in MU2 to the eastern end of MU3.** Such consideration would need to involve engagement with statutory stakeholders including the Environment Agency and Natural England, as well as local communities. A marine licence is also likely to be required from the Marine Management Organisation (refer to Section 1.6.1).

Recycling sediment in this way is likely to only speed up natural processes whilst having the benefit of increasing beach levels in MU3 and reducing amount of sand blown from the beach onto the promenade and highway (thus reducing clearing costs to EDDC). Should this operation occur, a period of intensive monitoring for at least two years should occur to monitor how the recycled sediment re-distributes itself along the BMP frontage. This will provide further information for future management decisions.

## 5.2.3 Beach recharge

No beach recharge is expected to be required along the BMP frontage before the BMP review in 5 years' time (Atkins/Halcrow, 2013). However, should beach recycling be insufficient in the future to provide required beach levels along the Exmouth frontage, recharge of the beach using imported sediment may

be required. At the time beach recharge is considered, review and update of the detailed analysis of recharge volume, placement and associated groyne configuration presented in the numerical modelling work (Appendix E) and options appraisal (Appendix D) should be undertaken, along with consideration of all other potential options to ensure that the most technically, environmentally and economically sustainable management of coastal flood and erosion risk is delivered for the Exmouth BMP frontage.

## 5.3 Alarm trigger level works

If the Alarm Level (refer to Section 3.2.3) is reached, the primary response will be to undertake more frequent monitoring of the beach levels through visual inspection (refer to Section 4.2.7) to determine if it is persistent or if it is merely a temporary occurrence as a result of naturally dynamic beach level fluctuations. This more frequent monitoring will ensure that if the beach level lowers further to the Crisis Level, then this will be observed in a timely manner and not be missed by less frequent planned beach profile surveys.

In addition to increased frequency of monitoring, if the Alarm Level is reached then consideration should also be given to recycling beach sediment along the frontage. Any decision to undertake recycling in this situation will need to be based upon an assessment at the time of the beach volume distribution along the Exmouth BMP frontage, and need to consider (a) the sediment grading of the material to be recycled, and (b) if recycling of material from one area to another will adversely affect beach levels, and so Standard of Protection, in the source area (refer also to Section 5.2.2).

If Alarm Levels persist, then implementation of a beach recharge campaign could also be considered (refer also to Section 5.2.3).

## 5.4 Crisis trigger level works

If a Crisis Level (refer to Section 3.2.3) is identified as being reached on a profile along the Exmouth frontage, the immediate task would be to carry out a visual inspection of the profile(s) concerned to validate the survey data and that it is representative of the general beach area (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.

Ultimately the response to the Crisis Level being reached along a sizeable length of the seawall will be for capital works to be carried out. If not already in process, then planning and implementation of capital works should begin (refer also to Section 5.2.3).

However, it is likely that the Crisis Level will occur as a result of a storm event that erodes a large amount of beach material over short period of time. Therefore whilst the ultimate response of capital works is being planned and implemented, a short term measure may be to place rock armour along the toe of the seawall to ensure that the risk of the seawall being undermined is reduced. The need for this will depend on what the seawall is founded on and this should be clarified by the undertaking revised trial pits work in the immediate future (refer to Section 3.2.2).

**Should the revised trial pits work find that there would indeed be a need to install emergency rock armour to reduce any immediate risk of undermining (i.e. if the seawall is founded in soft geology that could be eroded down if exposed), then in order to be in a position to implement rock armour in a rapid time-frame should the situation ever arise, analysis should be undertaken to determine (a) the appropriate size of rock to place in a crisis situation, such that it is large enough to withstand the forces it will encounter, and (b) the source of rock that will be used, noting that any possible source must be near to the site and readily available whenever it may be required; this should also consider the viability of creating a local stockpile near to the site as a way of ensuring this ready availability.**

## 5.5 Implementation of works

Should any works described in Sections 5.2 to 5.4 be required along any part of the BMP frontages, which will be guided by ongoing monitoring (refer to Section 4), then the items detailed below will form important considerations for actual implementation of any works.

### 5.5.1 Plant requirements

No specific plant requirements are defined in this BMP.

The plant required to undertake capital works will depend upon the nature of the works and should be considered by the designer and contractor at the time any such works are to occur along the frontage covered by this BMP. A key factor in this regards will be the capacity of the access points (refer to Section 5.5.2).

### 5.5.2 Access

When any works are to be carried out along the Exmouth frontage, consideration will need to be given as to the access requirements given the size of any plant being considered, and with regards to the soft (mud) foreshore conditions and limited tidal window for working along the respective frontage.

However, the following locations are likely to be suitable for plant access to the beach (see also Figure 5-1):

A. Access ramp at the eastern end of Queen's Drive.

B. Access ramp approximately 130m west of the RNLI lifeboat station off of Queen's Drive.

C. Access ramp/slipway adjacent Harbour View Café at the western end of Queen's Drive.

D. Access ramp/slipway from the Esplanade at the junction with Carlton Hill.

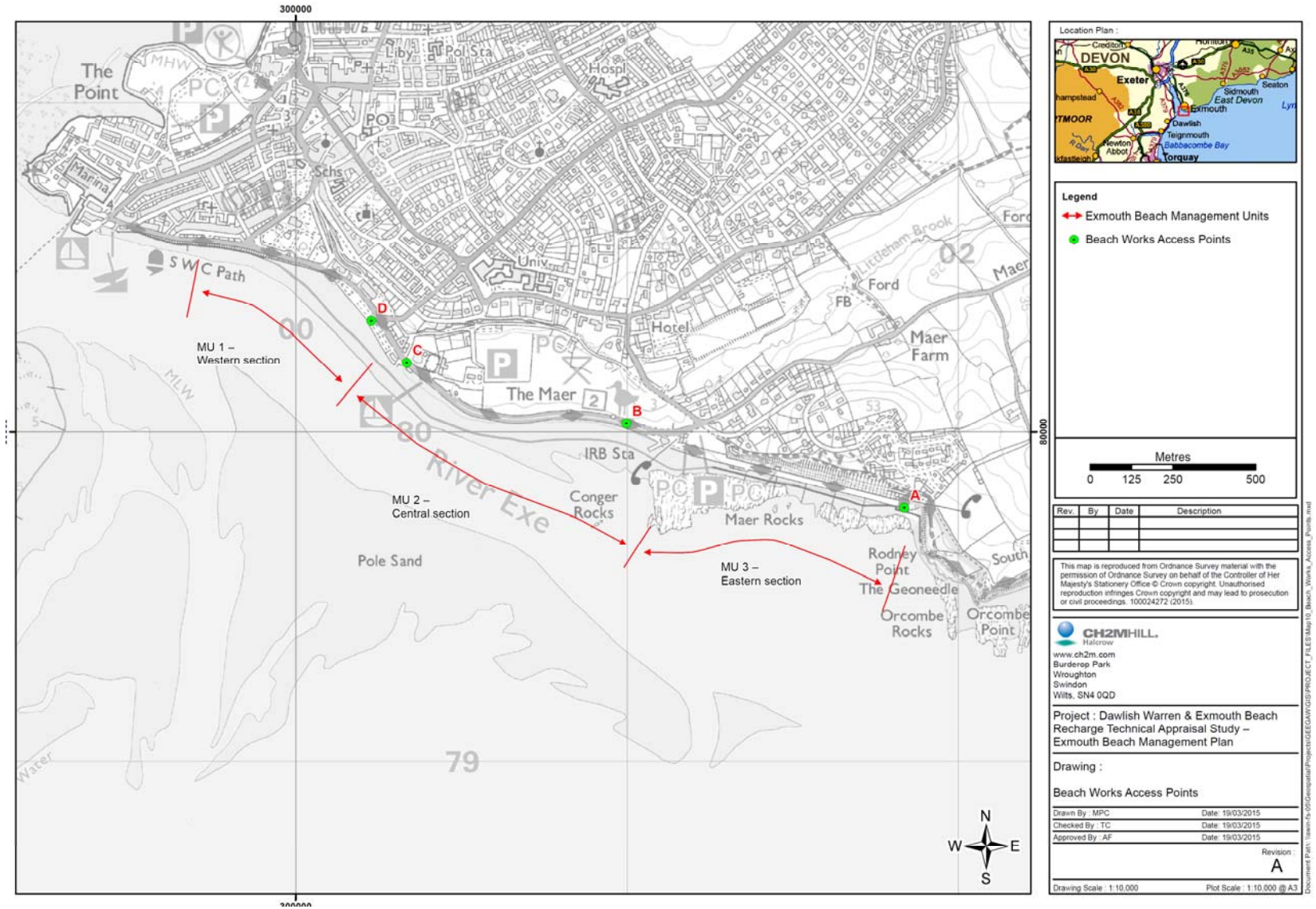


Figure 5-1

**Access points to Exmouth Beach when undertaking works**

### 5.5.3 Public access, amenity and safety

**Beach and coastal defence works, when they are required, 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.**

Experience elsewhere has shown that closing the beach entirely is likely to be impractical, **and it is suggested that a banks-man is present with each machine, and that spare personnel along with signage are employed to direct public access to safe sections of the shoreline 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 J contains a best practice guide on how to communicate with the public and local businesses when undertaking beach maintenance works.

### 5.5.4 Notifying others

In addition to communicating effectively with the public (refer to Section 5.5.3), **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:**

- The local Town and Parish Councils;
- The Crown Estate;
- Exe Estuary Harbour Authority (Exeter City Council);
- Local fishermen 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;
- RNLI Exmouth lifeboat station;
- Natural England (in relation to nature conservation and coastal access interests);
- Devon Historic Environment Service (in relation to historic environment interests).

# 6 Action Plan

## 6.1 Overview

This section provides a summary of the recommendations made above in the form of an Action Plan (Table 6-1). The Action Plan is presented below and identifies actions grouped by type as being either for 'Management', 'Monitoring', 'Maintenance' or 'For Future Studies', although there is some inter-relationship between these broad action types.

It is intended that this Action Plan be used to guide future management of this area.

TABLE 6-1
**Exmouth BMP 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 the BMP in 5 years' time. | EDDC | May 2015 | April 2020 | Section 1.2 | Not started |
| **MAN_002** | Measures should be taken by EDDC in the immediate future to establish a funding partnership to ensure that future delivery of any flood and coastal erosion risk management works at Exmouth can be both (a) delivered in a way that is preferred by the local communities (i.e. potentially fund beach recharge not just beach recycling) and (b) funded at the time when it is required and not depend solely on the availability (or lack thereof) of FDGiA funding. This is especially important given plans for extensive redevelopment of the Queen's Drive part of the BMP frontage which will require ongoing coastal defence. | EDDC | May 2015 | April 2016 | Section 1.4.1 | Not started |
| **MAN_003** | It is strongly recommended that a Scoping Opinion be sought from the MMO in the immediate future to determine if a Marine Licence is required for beach recycling and, if needed and given the time-scale involved in obtaining a Marine Licence (typically 14 weeks), obtain a Marine Licence from the MMO in good time to enable beach management works to be implemented when it becomes required, | EDDC | May 2015 | December 2015 | Section 1.6.1 | Not started |
| **MAN_004** | Consideration should be given in the immediate future to moving sediment from the now depleted sand dunes in MU2 to the eastern end of MU3. Such consideration would need to involved engagement with statutory stakeholders including the Environment Agency and Natural England, as well as local communities. A marine licence is also likely to be required from the Marine Management Organisation | EDDC | May 2015 | December 2015 | Section 5.2.2 | Not started |
| **MAN_005** | Ensure that as part of the Dawlish Warren Beach Recharge Scheme, that funding of detailed and ongoing monitoring along the Exmouth frontage and of the nearshore area is implemented in line with the monitoring requirements defined in Section 4 of this BMP. | EDDC | May 2015 | As part of ongoing EDDC engagement on Dawlish Warren Beach Recharge Scheme | Sections 1.4.4, 4.2.1 and 4.2.5. | Not started |
| **MONITORING ACTIONS** | | | | | | |
| **MON_001** | It is recommended that the January 2014 trial pit inspection is revisited to provide better quality data on the arrangement of the toe, including toe level and founding material. This information should be used to assess action levels for beach draw down and associated undermining risk. | EDDC | May 2015 | December 2015 | Section 3.2.2 | Not started |
| **MON_002** | Monitoring of beach profiles every spring and autumn by PCO will continue. | EDDC | May 2015 | Ongoing (as part of SWRCMP) | Section 4.2.1 | Ongoing |
| **MON_003** | It is recommended that the last 3 digits of at least some, if not all, of the Profile IDs listed in Table 4-2 be marked upon the seawall at Exmouth to allow ease of identification during future walkover inspections of the area. | EDDC | May 2015 | December 2015 | Section 4.2.1 | Not started |
| **MON_004** | A number of local authority staff who are regularly on-site should be encouraged to report to a key contact in East Devon District Council and/or the Environment Agency as to when a storm event has occurred and resulted in notable change in the beach levels against the seawall and groynes. The key contact in East Devon District Council and/or the Environment Agency can then call-out post-storm surveys via PCO. To support this, some basic training should be provided to the staff who are regularly on-site so they know what to look for. This could be based upon the Environment Agency's *Condition Assessment Manual* (Environment Agency, 2012) or key beach crest levels marked upon the seawall (refer also to Section 4.2.7). The arrangements for this, once confirmed, should be captured in a formal communication document so that the role can be communicated to others in the future. | EDDC | May 2015 | October 2015 | Section 4.2.2 | Not started |
| **MON_005** | Pre-storm profiles to occur if (a) sufficient understanding of the conditions of most concern can be developed through continued capture and review of post-storm surveys in the coming years, and (b) opportunity arises and/or funding is available. | EDDC | May 2015 | If opportunity arises and/or funding available | Section 4.2.2 | Not started |

| Action No. | Action Description | Who by? | Date action First Defined? | When by? | Related BMP Section | Current Status |
|---|---|---|---|---|---|---|
| **MON_006** | A survey of underlying bed level could be undertaken if the opportunity arises and/or funding is available. This data will provide a definitive 'Master Profile' for use in beach profile analysis. | EDDC | May 2015 | If opportunity arises and/or funding available | Section 4.2.3 | Not started |
| **MON_007** | The bathymetric survey information collected by the harbour authority should be reviewed alongside bathymetry and beach profiles survey data collected by PCO to further develop understanding of the sediment transport processes around the mouth of the Exe Estuary as part of future studies. | EDDC | May 2015 | April 2020 | Section 4.2.5 | Not started |
| **MON_008** | Visual walkover inspections should be undertaken by East Devon District Council and to monitor beach crest level against the seawall and groynes at Exmouth. 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. | EDDC | May 2015 | Ongoing | Section 4.2.7 | Not started |
| **MON_009** | These visual walkover inspections (refer to Action No MON_008) should also measure 'dip levels' along the frontage (i.e. distance drop from the seaward edge of the seawall to the beach to capture useful information about the variation in beach level against the seawall | EDDC | May 2015 | Ongoing | Section 4.2.7 | Not started |
| **MON_010** | To ensure the hard-defence assets (seawalls, groynes etc) remain in such condition, ongoing maintenance is required and this will be informed by regular re-inspection of the defences in a similar way to that reported in Appendix A at least once every two years, although annually would be preferable if budgets allow. | EDDC | May 2015 | May 2017 | Section 4.3.1 | Not started |
| **MON_011** | Full structural inspections of the Exmouth coastal defences should be carried out every five years. | EDDC | May 2015 | April 2020 | Section 4.3.2 | Not started |
| **MON_012** | Visual inspections should seek to identify any impacts on these features as a result of beach works (or indeed if 'new' features are uncovered by storm events). In the event of impacts or new features being identified, then the Devon Historic Environment Service should be contacted | EDDC | May 2015 | Ongoing | Section 4.4 | Not started |
| **MON_013** | Details of the storm conditions (waves, winds and water levels) will need to be recorded in support of the post-storm profile surveys. | EDDC | May 2015 | Ongoing | Section 4.5.2 | Not started |
| **MON_014** | To aid future understanding, a local wind gauge located along the promenade at Exmouth should also be installed to record wind speed and direction as both can have a significant impact on the effect of storm events on the beach response. | EDDC | May 2015 | If opportunity arises and/or funding available | Section 4.5.2 | Not started |
| **MON_015** | Each year a review of all survey data should be carried out with particular focus on trigger levels defined in Section 3.2.3 and associated coastal flood and erosion risks. | EDDC | May 2015 | If opportunity arises and/or funding available | Section 4.7 | Not started |
| **MAINTENANCE ACTIONS** | | | | | | |
| **MAI_001** | Should beach recycling works occur in the future, then beach recycling logs are to be maintained by those undertaking the works, with the records then being passed to East Devon District Council, PCO and The Crown Estate. This could be supported by completing a pre- and post-beach recycling survey for the first one or two beach recycling campaigns to provide actual data against which the recycling logs can be validated. | EDDC | May 2015 | As required. | Section 4.2.4 | Not started |
| **MAI_002** | If beach recycling or beach recharge occurs in the future, there will be a need to undertake regular water quality monitoring to assess the impacts (if any) of moving/placing material along the shoreline. | EDDC | May 2015 | As required. | Section 4.4 | Not started |
| **MAI_003** | 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:<br>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).<br>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 I. | EDDC | May 2015 | As required. | Section 5.2.1 | Not started |

| Action No. | Action Description | Who by? | Date action First Defined? | When by? | Related BMP Section | Current Status |
|---|---|---|---|---|---|---|
| **MAI_004** | In respect of coastal defence maintenance requirements to the seawalls and timber groynes along the Exmouth frontage, Table 10 of Appendix A indicates the defects that should be addressed in the immediate future. | EDDC | May 2015 | April 2016 | Section 5.2.1 | Not started |
| **MAI_005** | In respect of public safety issues along the BMP frontages, the following issues need to be addressed in the immediate future (refer also to Appendix A):<br>• Provide permanent replacement for temporary access steps at points along Asset numbers 168679 and 113FAS3351002C02 (refer to Table 10 in Appendix A).<br>• Remove exposed piles from 'groyne 7' adjacent Lifeboat slipway to improve safety for beach users, monitor exposed piles as beach levels change. | EDDC | May 2015 | April 2016 | Section 5.2.1 | Not started |
| **MAI_006** | Beach and coastal defence works, when they are required, should avoid the peak holiday season, weekends and public holidays where possible. | EDDC | May 2015 | As required. | Section 5.5.3 | Not started |
| **MAI_007** | When beach maintenance works are being undertaken, the following measures should be taken:<br>• 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.<br>• It is suggested that a banks-man is present with each machine, and that spare personnel along with signage are employed to direct public access to safe sections of the shoreline during works.<br>• Information boards should be displayed whilst the works are being carried out to explain what is being done and why.<br>• Explicit notification of any works, and contact details should there be any queries, should be provided to the following organisations/groups as appropriate depending upon the location where works are occurring:<br>o The local Town and Parish Councils;<br>o The Crown Estate;<br>o Exe Estuary Harbour Authority (Exeter City Council);<br>o Local fishermen 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;<br>o Local residents directly affected by any road or access closures along the frontage when works occur;<br>o RNLI Exmouth lifeboat station;<br>o Natural England (in relation to nature conservation and coastal access interests);<br>o Devon Historic Environment Service (in relation to historic environment interests). | EDDC | May 2015 | As required. | Section 5.5.3 and Section 5.5.4 | Not started |
| **FOR FUTURE STUDIES/RESEARCH** | | | | | | |
| **FUT_001** | Should the revised trial pits work find that there would indeed be a need to install emergency rock armour to reduce any immediate risk of undermining (i.e. if the seawall is founded in soft geology that could be eroded down if exposed), then in order to be in a position to implement rock armour in a rapid time-frame should the situation ever arise, analysis should be undertaken to determine (a) the appropriate size of rock to place in a crisis situation, such that it is large enough to withstand the forces it will encounter, and (b) the source of rock that will be used, noting that any possible source must be near to the site and readily available whenever it may be required; this should also consider the viability of creating a local stockpile near to the site as a way of ensuring this ready availability. | EDDC | May 2015 | April 2016 | Section 5.4 | Not started |

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# Appendix A
# Coastal Defence Condition Assessment Report

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# Appendix B
# Standard of Protection Assessment

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# Appendix C
# Contact Details

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# Appendix D
# Options Appraisal

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# Appendix E
# Numerical Modelling Report

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# Appendix F
# Sediment Sampling

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# Appendix G
# Beach Recycling Log Template

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# Appendix H
# Defence Inspection Pro-forma

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# Appendix I
# Defence Repair Pro-forma

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# Appendix J
# Environment Agency Guide to Engagement

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Ash House
Falcon Road, Sowton
Exeter, EX2 7LB
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