PDZ 12. COASTAL SNOWDONIA:

Bae Tremadog/ Tremadog Bay

Traeth Dyffryn to Pen y Chain

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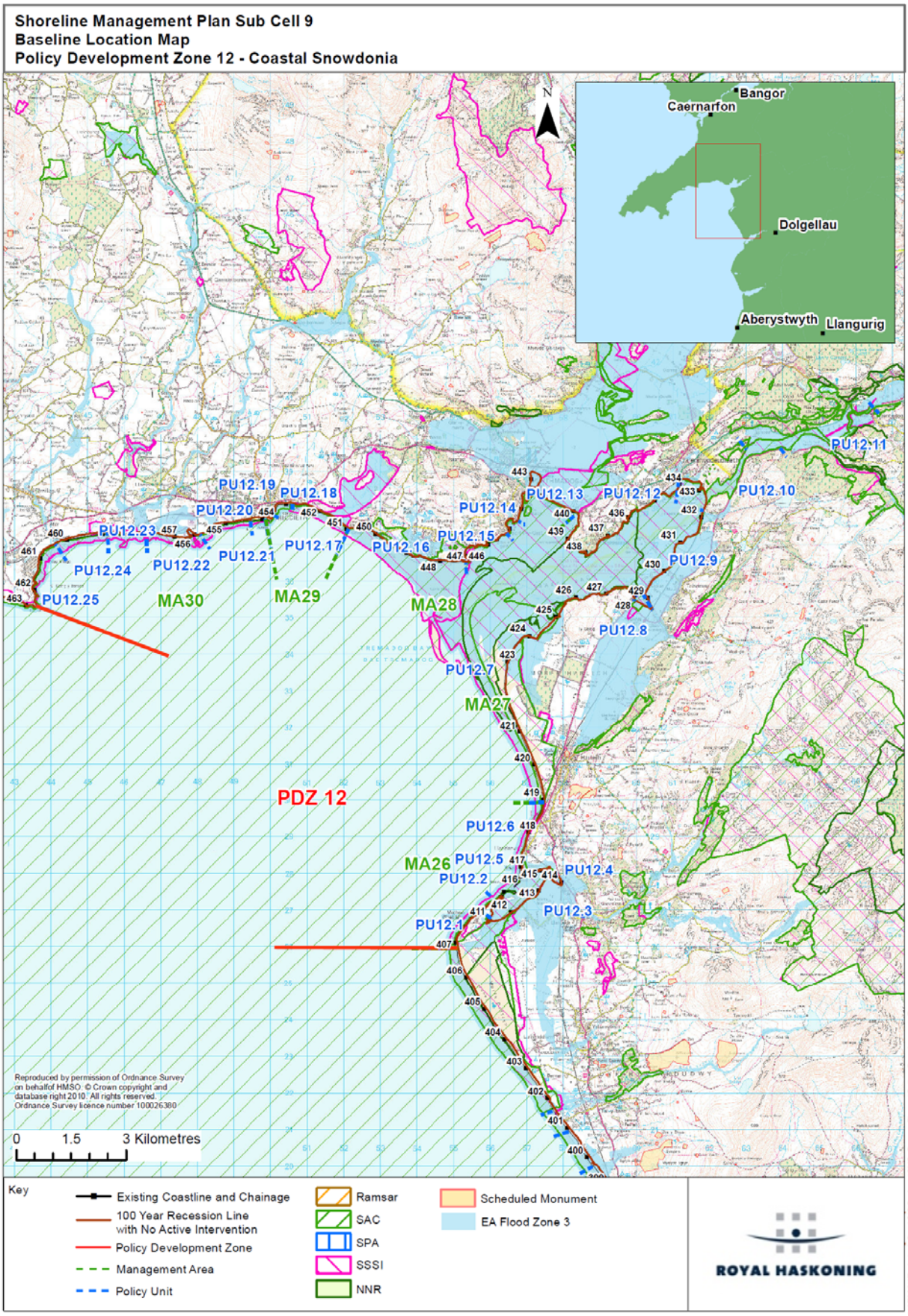
Shoreline Management Plan Sub Cell 9
Baseline Location Map
Policy Development Zone 12 - Coastal Snowdonia
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Key
Existing Coastline and Chainage
100 Year Recession Line with No Active Intervention
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Policy Unit
Ramsar
SAC
SPA
SSSI
NNR
Scheduled Monument
EA Flood Zone 3
ROYAL HASKONING

Definitions of Scenarios Considered in Policy Development

This section defines the various scenarios that are used throughout the discussion of the Policy Development Zone.

Sea Level Rise
It is recognised that there is a continuing uncertainty with respect to Sea Level Rise (SLR). Taking different SLR scenarios may affect the scale of impact or the timing of some changes, either in terms of sustainable management or in terms of impacts. In the discussion below of the baseline and alternative management scenarios, the Defra guidance on SLR has been generally been used. Where, in any specific area, the impact of SLR is felt to be significant and may change the context of management this discussion is held within a separate box, relevant to that section of text.

Management scenarios;

Unconstrained Scenario
Under this scenario, the behaviour of the coast is considered as if there were no man made defences, effectively if they were suddenly not there. Although recognised to be a totally theoretical scenario it does provide a better understanding of how we are influencing the coastal behaviour and therefore the stresses and broader scale impact that are introduced. This assists in assessing first how the coast might wish to change, but also in defining the limits of interaction which the SMP should be considering.

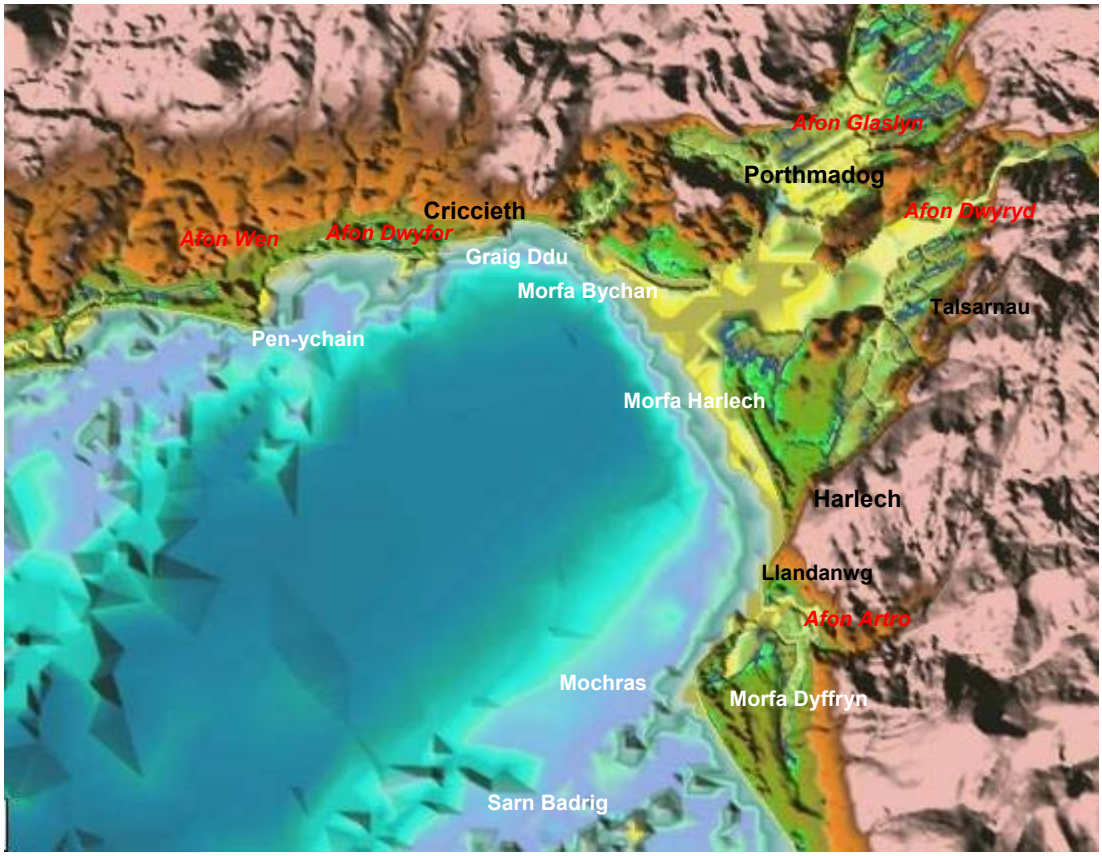
Baseline Scenarios
- ***No Active Intervention (NAI) – Scenario 1****, where* there would be no further work to maintain or replace defences. At the end of their residual life, structures would fail. There would be no raising of defences to improve standards of protection.
- ***With Present Management (WPM)– Scenario* 2**. This scenario applies the policies set in the SMP1 or, where relevant, takes updated or clarified policies, if subsequent work has been undertaken e.g. studies or strategies. In many locations, the approach to management defined by SMP1 only covers a 50 year period. Where this is so, the intent of how the coast is being managed has been assumed to apply into the future. It should be noted that WPM does not necessarily imply a Hold The Line approach throughout the zone, in many areas present management may be for a No Active Intervention approach or one of Managed Realignment.

The aim of the No Active Intervention is to identify what is at risk if defences were not maintained. In a similar way, With Present Management aims to examine how the coast may develop, identifying where there are benefits in this management approach or where there may be issues arising in the future.

At the end of this sub-section a brief summary and comparison of the economic risk for each of the baseline scenarios is provided, based on the MDSF analysis undertaken during the SMP (including other study findings where relevant). The baseline scenarios are also assessed in terms of how they address the overall objectives for the Zone. This comparison between the baseline scenarios sets the scene for discussing possible alternative management scenarios which better address all the issues. This discussion is provided in the subsequent sub-section.

1 Local Description

The zone extends a distance of some 55km, extending from Mochras through to Pen-ychain, covering the north western head of Bae Tremadog. To the south is the large dune system of Morfa Dyffryn, north of the Afon Artro Estuary. Within the centre of the zone are the combined estuaries of the Afon Dwyryd and Glaslyn, enclosed by the large dune system of Morfa Harlech and that of Morfa Bychan to the north. The upper Glaslyn estuary is cut off by the Cob embankment, running between Penrhyndeudraeth headland ridge and Ynys Towyn at Porthmadog. Along the northern shore is Criccieth, with the town and castle sat upon its hard rock headland. West of Criccieth the nature of the coast changes to the glacial clay cliffs and shingle ridges around the estuaries of the Afon Dwyfor and Afon Wen.



Porthmadog and Criccieth are identified as an essential hub for regeneration, central to the economic development of the north western area of Wales. In addition to maintaining the traditional industries associated with slate mining, considerable effort has gone in to attracting more modern commercial development and inward investment in the area. This is strongly underpinned by the cultural heritage of the area and the superb natural landscape and ecological values. Much of the area lies within the Snowdonia National Park.

Harlech and Criccieth Castles are designated SAMs and the Cei Tyddyn Isa quarry, on the Dwyryd, and medieval Tomen Fawr ringworks, at Afon Wen, are similarly designated. The castle and the area around the castle at Harlech is a World Heritage site, important for its setting and historic landscape. The whole area to the south through to Porthmadog is designated as Landscape of Outstanding Historic Interest.

The whole area of the coast is designated as the Pen Llŷn a`r Sarnau/ **Llŷn Peninsula** and the Sarnau SAC and this designation extends to cover the Artro Estuary, the Dwyryd Estuary and much of Morfa Bychan. The Morfa Dyffryn and Morfa Harlech areas are designated separately as the Morfa Harlech and Morfa Dyffryn SAC and parts of the Coedydd Derw a Safleoedd Ystlumod Meirion/ Meirionnydd Oakwoods and Bat Sites SAC abut the edge of the Dwyryd and Glaslyn Estuaries.

The Glyn Cywarch; just south of Talsarnau, Portmeirion; situated on the Penrhyndeudraeth headland and Plas Tan-y-Bwlch; on the Dwyryd, are identified as Historic Parks and Gardens for their essential settings. The National Trust manages significant areas of the coast: over the dunes at Y Maes on the Artro Estuary and along part of the cliff line north of Llandanwg, within Morfa Harlech, at Ynys Tywyn at Porthmadog, at the Ynys Cyngar headland to Morfa Bychan and over a large extent of cliffs and within the valley of the Afon Dwyfor.

The zone is linked by the main railway line, which runs along the whole length of the coastline. The line runs behind Morfa Dyffryn, across the Artro Estuary, along the old coastline behind Morfa Harlech and across the Dwyryd at Pont Briwet. It then runs more inland across the Glaslyn some way north of the Cob, to the back of Porthmadog, before reappearing at the coast to the east of Criccieth and running across the Afon Dwyfor and at the shoreline across the Afon Wen valley towards Pwllheli. There is also the important local Ffestiniog Railway that runs down the Penrhyndeudraeth headland ridge across the Cob to Porthmadog. The main coastal road, the A437, tends to follow the route of the railway over the southern section of the coast, being someway forward of the railway line in the area of Morfa Harlech, actually running across the low lying valley between Harlech and Talsarnau. The road then runs to the rear of the railway line at Talsarnau, following the valley of the Dwyryd to join the A470, which then runs to the north of the estuary along the Penrhyndeudraeth headland, across the Cob to Porthmadog. A minor toll road continues with the railway across the Dwyryd at Pont Briwet. Along the southern Llŷn Peninsula the main road tends to run well back from the coast between Porthmadog and Criccieth and to the back of the Afon Dwyfor and Afon Wen flood plains through to Pwllheli.

While over the northern section of the zone the road and railway provide important strategic links through to the Llŷn Peninsula, along the southern section these transport routes also play an essential local role in maintaining access to and connection between the string of villages all the way from Barmouth through to the northern centre around Porthmadog.

Mochras

At Mochras, in the south, the headland acts as a fixed point to the Morfa Dyffryn dune system to the south. The headland is a relatively high clay cliff to a boulder strewn foreshore that runs out to link with the wide shoreline root of the Sarn Badrig. The Afon Artro estuary, up to the early 1800s opened to the sea south of the Mochras. This had closed by the 1830s with a new entrance forming created by a breach in the thin ridge to the north of the headland. The old channel apparently rapidly filled with dunes and now forms a wide dune area at the

northern end of Morfa Dyffryn. There is some suggestion from the bathymetry that the old estuary channel cut through the root of Sarn Badrig, with the main Sarn running to the coast to the south and a shorter Sarn feature running from Mochras headland.

The boulder clay cliffs of Mochras reduce in level moving north and run into the now defended spit to the southern side of the estuary. This spit provides protection to a significant extent of moorings within the southern part of the estuary and a small marina has been created within this area of protection.

To the northern side of the estuary the mole, a sheet piled jetty maintained by the Environment Agency, has been built over the high natural tidal ridge of boulders and stone. The main channel, either cut or developed naturally with the breach of this ridge, is quite narrow and the jetty only appears to focus the upper tidal flow, rather than control the main channel. This is fronted by a shingle upper beach which runs through to a narrow ridge of dune over the harder tidal platform. At the landward end of the jetty is a yacht club and the area within the estuary behind the jetty and dune is again used for moorings. Although not formally owning the dunes, the dune ridge is under the stewardship of the local Llandanwg Dune Protection Group, who, with local support, have undertaken various works to maintain the dune integrity through sand fencing and Marram planting.

The estuary is a curious shape, with the entrance formed, in effect, into the side of the old estuary that ran in a northeast/southwest direction. To the south of the entrance the channel is maintained by drainage from the old truncated seaward section of the estuary behind Mochras. To the north the estuary narrows between defences to the mouth of the Afon Artro, which then runs south and then in land through the village of Llanbedr. The river joins the larger defended drainage valley running south behind the main ridge of Morfa Dyffryn. The whole system, therefore, even in its early natural state, seems to have acted far more as an inlet, reinforced by the river flow, than as normal estuary.

The main ridge behind the active Morfa Dyffryn Dunes is occupied by the old RAF airfield, with the longest north/ south runway extending down to the narrower section of the dunes. The main buildings associated with the airfield are at the northern end, within the old flood plain of the estuary. There

are discussions concerning re-opening the airfield for commercial use and this is seen as a potential means of attracting further investment to this remoter part of the area.

The northern area of the dunes, to the rear of the main active section of the in filled valley, is part of a popular camping site, which extends over much of the Mochras headland. The main facilities to this camp site are on the headland set well back from the seaward cliffs.

Access to the airfield is across the flood plain of the valley to the rear of Morfa Dyffryn and access to the headland and campsite carries on from this along the side of the estuary on the seaward site of the various defences. Access to the headland can, therefore be tidal.

The main development in the area is the villages of Llanbedr and Llandanwg. The Main road and the railway line run in part through the old estuary flood plain through these villages. At the southern end of Llandanwg, seaward of the railway line, there are properties within the dunes. In this area there is also a car park and the Church of St Tanwg, a grade 1 listed building. The dunes at the northern end of the north estuary spit tend to be healthier than to the south and these dunes run further north into the higher headland of Llandanwg and Llanfair. The railway line runs behind defences along this headland through to the southern end of Morfa Harlech.

Morfa Harlech extends some 6km in a north northwest direction, infilling the southern side of the Glaslyn/Dwyryd valley, forming a large V shaped area of natural in-fill against the old cliffed coastline which runs to the northeast. The area may be described in three principal areas. In the centre is a slightly raised ridge of land extending from the Llanfair headland through to the high rock hill of Ynys Llanfihangel-y-traethau. To the southern end of this ridge is Lower Harlech and the Royal St David's Golf Course, all overlooked by the castle and old village set up on the cliffs of the old coastline. The main road drops from this high ground to run along the ridge and along the eastern flank of Ynys Llanfihangel-y-traethau. Just to the southwest of the rocky hill, is an area presently used for landfill at Ffridd Rasus. The village of Ynys is located at the foot of the hill on its eastern side.

Seaward of the ridge and extending over the southern end of the ridge is the main massive area of sand dunes. This dune area fans out at its northern end as a series of dune ridges

demonstrating the progressive growth and infill of the estuary mouth. Part way along the dune frontage, set back behind the main dune ridge, is an old site of a sewage works and pumping station. An outfall pipe runs through the dunes to the sea at this location.

On the western side of the ridge is a large expanse of low lying land, believed to be the old sea channel to Harlech Castle but now enclosed by Morfa Harlech, infilled with sediment and defended across its north end by embankments between Ynys and Glan-y-wern. The Afon y Glyn and Eisinrug flow down to this low lying valley at Glan-y-wern. The main railway line runs centrally through the valley and there is station at the northern end where the road cuts back across the valley mouth behind the defences. The land use within the valley is agricultural. Drainage of the valley is via sluices and tidal gates and through the marshes of the southern side of the Dwyryd Estuary.

Harlech

North of Morfa Harlech, the outer part of the Dwyryd is formed within the continuation of the old coastline on the eastern side and the Penrhyndeudraeth headland ridge to the northwest. The broad main channel tends to favour the northern side of the estuary, with extensive areas of saltmarsh along the south eastern side. There are defences to this eastern side at the back of the marsh at Glastraeth. These defend mainly agricultural land but with the small community of Draenogan Mawr on a slightly raised hillock and the railway line. The lower part of Talsarnau, with its station, school and sewage works, all lie within the flood plain behind the railway line. The main road, running along the toe of the old coastal slope, generally defines the limit of the present tidal flood plain.

At the northern end of this section, the railway line cuts across the flood embankment and forms the main defence to the small valley formed between the headlands of Bryn Glas and Y Garth. There is a sewage works within the valley and the toll road and main road both cross the valley. The Garth headland forms the southern control point where the Dwyryd narrows into the steep sided gorge that forms the entrance to the upper estuary. The railway and toll road cross this entrance on the Pont Briwet, with the bridge embankments acting to narrow the estuary. The toll road is an important and well used local route from the communities to the south through to the Porthmadog area and there are plans to improve the railway bridge.


Portmeirion

At the northern head of the outer Dwyryd estuary is a wide expanse of saltmarsh with the road and railway line running to the back at the toe of the steeply rising land of the Penrhyndeudraeth ridge. The main power lines from the inland Trawsfynydd Power Station to Porthmadog cross the estuary, with pylons protected against scour.

There is a small area of reclaimed farmland and properties over the area of marsh and this then gives way to the generally hard rock rising land of the Penrhyndeudraeth ridge. Further along this ridge is the village of Portmeirion, with its small shoreline terrace and myriad of listed buildings rising up the slope behind. The hard rock headland continues around to Trwynypenrhyn, forming the division between the Dwyryd and the Glaslyn.

From Pont Briwet, the Dwyryd continues up through the gorge before broadening into the tidal valley of the Vale of Ffestiniog. Within the flat valley floor the meandering river channel is in part constrained by the steeper hard rising land defining the valley and in part is kept in channel by various defences to agricultural land over the valley floor. The main coastal road from the south runs to the toe of the steeper valley slope through to Maentwrog, where it joins with the main west coast A487 from Dolgellau. The A487 crosses the valley and runs just within the edge of the tidal flood plain along the northern side of the valley. The normal tidal limit is at the bridge, but the potential tidal flood plain extends some 600m further within the valley.


The Cob

The Glaslyn estuary is cut by the Cob, effectively excluding a major part of this estuary's tidal prism (volume). The Cob, constructed in 1811, breached in 1812 and repaired and completed by 1814, runs a distance of some 1.5km between Penrhyn-isaf and Ynys Tywyn, on the Porthmadog side of the estuary. Tidal flow upstream of the embankment is controlled by tidal gates from the defended tidal pool of Llŷn Bach up stream of the Brittania Bridge between the small island of Ynys Tywyn and the main area of Porthmadog. This creates semi tidal and brackish marsh in the area directly upstream of the embankment. Tidal locking of fluvial flows from the Glaslyn results in some flood risk in the lower parts of the wide impounded estuary. Much of the lower area of Porthmadog sits within the tidal flood plain of the old estuary.

Significant areas seaward of the embankment have developed as saltmarsh, particularly to the eastern end of the embankment where the old river channel used to flow. The Glaslyn is now taken out on the western end and, aided by sluicing from upstream acts as the main navigation channel through the dock area of Porthmadog. This area of the town has benefited from significant investment and, while the navigation through the estuary is difficult, Porthmadog is an important sailing centre, with moorings within the channel just off shore of nearly 1km of the quayside.


Porthmadog

The main river channel continues along this side of the estuary and just to the south of the quay is the small bay of Borth-y-Gest. This muddy bay is defended around its perimeter. There are a substantial number of properties both around the bay and to the hill side behind the bay. Access to the properties relies on the road running around behind the defences. To the south of the village is the Garreg-goch headland and beyond that the generally sandy Samson Bay.

The channel of the Afon Dwyryd joins that of the Glaslyn, typically between Borth-y-Gest and Samson Bay. The change in position of the Dwyryd channel is identified as a principle cause of erosion within Samson Bay that resulted in a rock defence being placed to the face of the eroding dunes.

The Ynys Cyngar headland, south of Samson Bay, forms the main hard control point on the northern side of the estuary and is directly opposite the north western tip of Morfa Harlech. To the east of Ynys Cyngar is 3km length of the Black Rock Sands dunes, built out in front of Morfa Bychan. The eastern end of this shoreline sweeps around in a curve into the estuary, with the intertidal foreshore extending out as the large North Bank forcing the main estuary channel to the south. To the west of the frontage the dune line is very straight through to the hard rock headland of Graig Ddu. The main development in the area is to the eastern end, where there is greater width of flat land before the land levels rise steeply to the rocky hills behind. Much of this wider area is taken up by the large caravan parks, namely Greenacres Holiday Park, Garreg Goch Caravan Park and Cardigan View Holiday Park. The main village of Morfa Bychan is set back behind the caravan park along the principal road through the area. To the western end of the town is a small stream valley and to the side of this the centre of the Holiday Parks. Further west, as the width between the back hillside and the dunes becomes narrower; the road runs close to the back of the dunes. There is a car park in this area and small camp sites.

The area is very important for tourism and this tourism, and the caravan parks, help sustain essential services to the village beyond the tourist season. There is vehicular access onto the beach which is used as a car park during the summer months. There are concerns, however, that over-use of the dunes, particularly use of vehicles, is causing a deterioration of both the natural value and that of the dune as a flood defence.

There is a very noticeable change in the coast moving west from Graig Ddu both locally in the step in shoreline position and also in the nature of the shoreline. To the west of Graig Ddu there is a shingle bank across the entrance to the Llyn Ystumllyn valley, blocking a former tidal inlet. The drainage of the valley is taken out close to Graig Ddu and significant drainage works have been undertaken over the valley floor. It is suggested (Steers) that the former natural channel was to the western side of the valley. The main railway line runs through the valley to run directly behind the shingle ridge in front of the Rhiw-for-fawr headland to the west of the valley; the railway is cut into the rock of this headland.

The shingle ridge, with the railway behind continues through to the boulder clay, Merllyn promontory at the western end of the Criccieth promenade. This is a geological SSSI.

The railway runs behind this promontory, slightly in land through Criccieth. The dominant feature of Criccieth is its castle sat on the high hard rock headland in the centre of the town's coastal strip. To the east of the Castle is the public slipway and main tourist sea front. The coastal cliff immediately to the east of the main headland is of weaker material and in the past there has been cliff falls that have threatened properties. The face of the clay cliff is protected from weathering by a timber crib, and the toe of the cliff is protected by rock and which extends through to the harbour breakwater. From the breakwater through to the Merllyn promontory there are various seawalls and defences, with the road behind set at a relatively high level. Behind the road is a slight coastal slope with properties. The Esplanade over the eastern end was improved during the late 1990s, with a strong emphasise of improving important car parking and improving the seafront to the town for tourism. The relatively high beach comprises shingle down to low water with some local areas of sand.

The west of the castle, Marine Crescent and Min-y-Mor is protected by a high sea wall, which reduces in height from the castle moving west. To the rear of the road are a row of houses. The foreshore is relatively steep and comprises shingle and boulders, with a more substantial shingle beach built up against the Castle headland.

From this point west, the lower foreshore tends to be relatively tough densely packed glacial stone, which extends out below low water. Between Criccieth and the Afon Dwyfor this platform is backed by low cliffs with a shingle wedge to the toe of the cliff. The land rises slightly at the eastern side of the Dwyfor and the headland stands proud of the alignment of the coast with the shingle spit across the mouth of the river further enhancing this forward position of the coast. The Dwyfor forces its way through this shingle spit, held hard against the high ground to the east. The valley of the river is quite wide in land of the coastal ridge, although the actual river channel is quite narrow. The shingle ridge acts more as a barrier to the wider inlet behind rather than a true estuary spit. The flow of the river creates a wide fan of sediment across the high foreshore platform.

The ridge of shingle continues west some 1km across the entrance to the valley before running to a further length of higher boulder clay cliffs. There is relic evidence of this

higher land extending further seaward in the raised areas of the stony foreshore platform. These cliffs are designated SSSI for their geological importance. These cliffs form the inland ridge between the valley of the Afon Dwyfor and that of the old coastal plain of the Afon Wen.

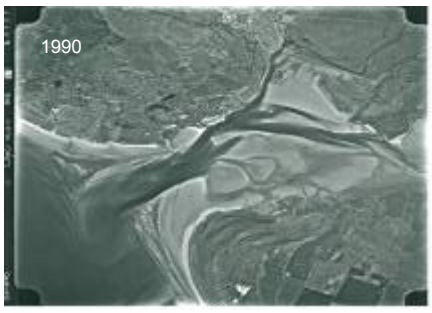
The main railway line returns to the coast across the valley of the Dwyfor, still set back some way, behind the ridge of boulder clay to then run along, closing off the marsh area of the wider Afon Wen valley. This section is heavily defended with concrete walls and rock revetment, which has been extended east as the boulder clay cliff has eroded back. This defence continues to the west through to the Afon Wen itself, beyond the point were it cuts the coast. The back shore reverts to clay cliff and follows in a curve to the Pen ychain headland.

Between Criccieth and the Afon Wen, the land behind the shoreline is primarily agricultural; with isolated properties close to the cliffs. Behind Pen ychain is the large Holiday Park and part of its main centre is situated close to the crest of the clay cliff. This is protected by a sheet piled wall and rock revetment. In this area is also a sewage works.

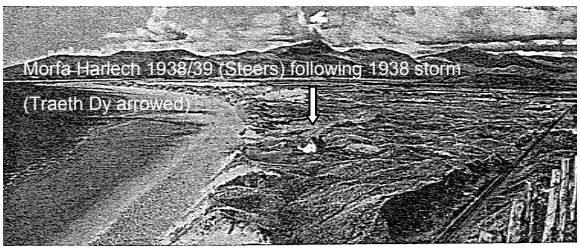
2 Coastal Processes

The offshore wave climate is dominated by energy from the southwest. The Sarn Badrig provides a degree of shelter from more southern waves and the Llŷn peninsula from the west and north. This strong directional dominance drives energy though the deeper area of Bae Tremadog into the head of the bay. The steeply shelving nearshore bed and the large dunes systems give clear evidence of this large scale process driving sediment to the north east. Without the large estuary at the head of the bay, this coast line would be one continuous dune system with the pressure to roll it back in land.

The only counter energy is in the flow from the estuary, drawing sediment in from the adjacent shorelines and pumping sediment out through the central channel of the ebb. This influence used to be greater, prior to the closing off of the Glaslyn. There is evidence from photographs from the early 1900s indicating little dune width in front of Morfa Bychan until the 1940s (SMP1), suggesting even at that time greater influence of the estuary drawing sediment in along the frontage. As the estuary, still responding to the change in tidal volume, continued to accrete and with the constraint of the main channel more central between the two developing dune systems, this has allowed both the end of Morfa Harlech to accrete and the western nose of dune system to develop along the Morfa Bychan frontage. There has been, and can still be, significant change within the estuary, particularly with respect to change in the position of the Dwyryd and the way in which this combines with the Glaslyn channel, and this still influences the development along the shoreline. Even so the dominant process appears to have shifted in favour of that driven by wave energy driving sediment into the head of the bay, with the estuary having to cut its way through to the sea.

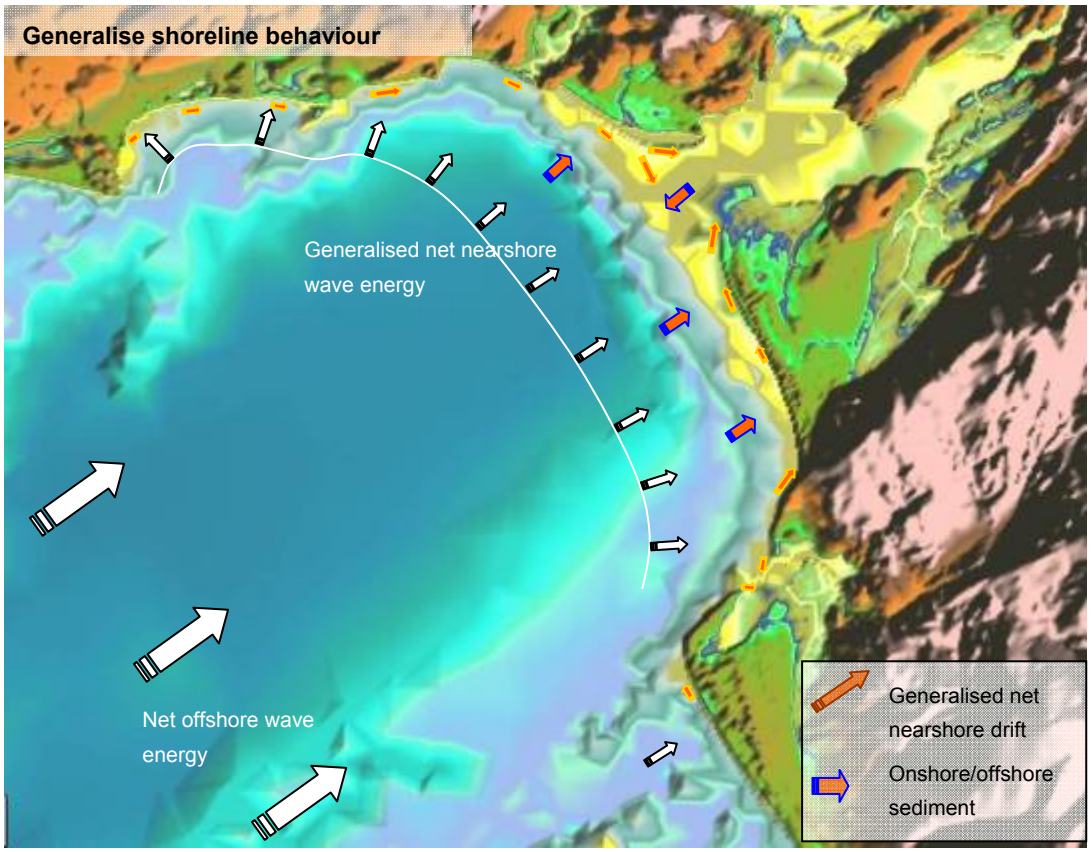


This dominant process has resulted in the main beach of Morfa Harlech remaining relatively stable. Although subject to significant variation, the following set of photographs demonstrate that: at the southern end of the dune system there has been change in form of the shoreline and the front dunes but little overall change in position



over some 70 years. The significant growth over the last twenty years reflects the ability of the beach to accrete during periods between major storm events. It also highlights how monitoring needs to be maintained over a long period of time to correctly identify the range of conditions. There is, however, some evidence of steepening of the intertidal zone but this is taken over a relatively short period of measurement.

In general, waves approaching from the southwest drive through the central deeper section of Bae Tremadog. These approach the coast head on, as shown on the generalised shoreline behaviour diagram below. Due to the presence of the Sarn Badrig to the south, with its associated shelving sea bed to the north of the main feature, and due to the harder platform of the south Llŷn peninsula to the north, the waves are refracted so as to approach more normally to the shores to the north and south. It should be noted that there is significant local variation in wave climate at the shoreline and local features that influence behaviour. However, the generalised picture of behaviour provides a framework within which to describe local evolution.



At the southern end of the zone, the relatively hard clay cliffs of Mochras, together with the boulder strewn foreshore, act to control the development of the northern end of Morfa Dyffryn. There is still sediment movement over the lower foreshore tending to create a lower foreshore spit in front of the northern dunes and the cliffs. This would suggest that there is also some continuing sediment supply within the nearshore area feeding north.

The southwest facing cliff line is eroding slowly but along the northwest facing shoreline this erosion is greatly reduced.

The main pressure for erosion has been more local to the southern spit to the Artro Estuary. Here drift would seem to be to the north, but locally in towards the estuary. There also appears to be some by pass of sand across the estuary, through the nearshore zone.

Along the northern shore, the main control feature is evidently the headland to the north but also, less obviously, the hard foreshore platform and influence of the estuary entrance to the south. The coast has set back between these two features to create a relatively stable bay. Quite clearly there is loss of sediment from the northern end and a continuation of the nearshore sediment drift to the north. However, what is also evident is the ability of the shoreline to retain sediment within this embayed frontage. This section of coast is very delicately balanced and this is seen through the monitoring undertaken by the Llandanwg Dune Protection Group.

Works were undertaken in 2002 to encourage accretion of sand to the dune face. This achieved a certain degree of success in subsequent years but any benefit derived was undone over a storm in 2008.

Two aspects of this are highlighted: that the present alignment is relatively stable in its ability to retain sediment under normal conditions, but there is insufficient width within the dune system to fully respond to more extreme events. This vulnerability is further exacerbated by the pressure on the rear of the dunes from the estuary preventing development of natural development of the dune. While there is obviously important linkage in terms of general sediment supply to the foreshore further

north (Morfa Harlech), local retention of sediment within the natural Llandanwg dune system is not seen as substantially impacting on this broader sediment system.

The pressure on the frontage to roll back will increase with sea level rise, this will further reduce the width for the beach and dune to develop naturally. Increased sea levels will also influence the development of the estuary. Although there is anticipated to be the potential accretion within the estuary, defences around the backshore of the estuary will constrain development of saltmarsh with the potential for habitat squeeze. The natural development of the National Trust area of dunes in the northern corner of the estuary is currently constrained by the limited supply and by the change in the channel position within the estuary.

Further south within the estuary system concern has been expressed that the airstrip may constrain future wind blown active development of the Morfa Dyffryn system as the whole system attempts to roll back. The main area of active in land dune development tends to be within the more recent infilled estuary mouth. Here there seems little conflict with land use behind; although the myriad of pathways do seem to impact on the natural active wind blown behaviour. There might be greater influence at the southern end of the main runway where the dune system is significantly narrower.

Further north along the Llandanwg frontage, the dune is reasonably healthy although subject to periods of erosion. Again with sea level rise, this frontage might be expected to come under increased pressure for erosion. This length has greater influence on the net shoreline drift supply further north, although this is seen as contributing to the nearshore supply of sediment to Morfa Harlech rather than comprising a major component of supply.

The headland at Llanfair is heavily protected by Network Rail. This was identified (Steers 1939) as potentially reducing the supply of shingle to Morfa Harlech. While undoubtedly true, this does not appear to have had any significant consequence on the long term behaviour of the southern shoreline of the Harlech Dunes.

As discussed earlier, while there is recognised to be a northerly drift of sediment along the Harlech, the main process at work is seen as being the slow setback of the whole nearshore and foreshore profile. This would inevitably expose a greater length of the old cliff headland to the south but this would not imply that maintaining erosion along this cliff is critical to the supply of sediment to the system to the north. With sea level rise the process of roll back will increase. While at present, changes along the frontage are seen very much as an intermittent process of erosion and accretion, there would be anticipated to be a more persistent change to one of retreat. It is very unlikely, over the main section of the dunes that there would be an actual breach in the system through to low lying land behind.

Flood management of the low lying land within the Harlech to Tygwyn valley behind Morfa Harlech is managed through sluices at the northern end at Ynys, through the defences in this area. With the general accretion of the estuary sluiced drainage is reported to have become an issue due to the management of the drainage ditches within the area.

This is reported to be having an increased impact on drainage in the area of the Royal St David's Golf Course. This is currently being looked at in terms of water level management and with respect to the potential impacts on nature conservation interests in the area.

The main process within the Dwyryd and Glaslyn Estuaries is one of accretion. A significant aspect of this is sand brought in from the nearshore and shoreline areas. There is, however, finer sediment accretion and this whole process could well be maintained in line with sea level rise. Some balance would be reached with channel width and depth and as such there could be some squeeze of saltmarsh around the estuary even though at present this is reported to be growing in area. The Dwyryd, in particular, tends move its position within the estuary and this results in change in behaviour of the shoreline and results in natural change in position and extent of saltmarsh areas. A recent study looking at options for redesign of the railway crossing at Pont Briwet indicted that change in flow through this section could result in local change in that area. The general pattern of accretion could impact on the sluiced drainage to the area behind Morfa Harlech.


The Cob

The current practise of allowing some tidal flow beyond the Cob clearly influences the development of the brackish marsh within the upper impounded section of the Glaslyn Estuary. With sea level rise this could alter significantly depending decisions regarding water level management. Clearly, with sea level rise, this will also impact on the potential tidal locking of fluvial flows within the Glaslyn Valley.

The Morfa Bychan dune system is more influenced by changes in the estuary than that of the main area of Morfa Harlech. There is a weak net drift towards the east along the frontage and from modelling it is suggested that this increases as one moves eastward. However, as identified in SMP 1, this would suggest an on going issue of erosion. While the central section of dunes has a history of periods of erosion, this is not identified as a major long term trend. As discussed in SMP 1, the effect of the estuary and the bank system has a major influence on this behaviour and while the central section can be more vulnerable to specific conditions, overall the frontage is seen as being relatively stable. The main longer term issue is one of the whole system rolling back with sea level rise.

The coastline west of Criccieth is increasingly influenced by the hard densely packed stony areas of nearshore bed and foreshore. The limited areas of sand either over the foreshore or the backshore are indicative of more limited supply, higher wave energy breaking over the harder platform and, within the foreshore area, the stronger eastward drift over the foreshore. The higher platform does, however, act to dissipate energy at the backshore and to modify wave direction such that drift rates are significantly reduced with respect to the shingle ridges along the frontage.

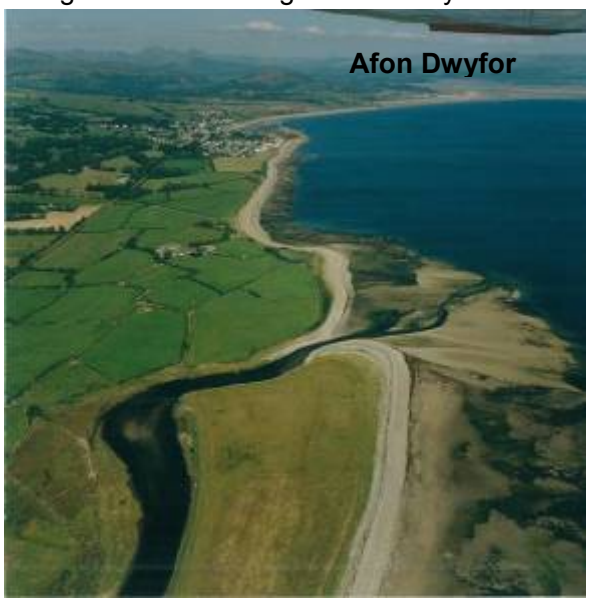
This platform, in effect, holds the shoreline forward and has slowed erosion, limiting the extent to which this area might otherwise develop the consistent sweeping crenulate bays seen further to the west along the Llŷn Peninsula. The basic shape is present and

this can be seen most notably where sediment has been allowed to build against the natural (or in the case of the main Criccieth beach, the easterly groyne) hard or semi-hard headlands of the frontage, such as the more prominent feature and the estuary entrance of the Dwyfor, the Castle Headland at Criccieth and Craig Ddu. This generally

is an eroding drift aligned frontage and only where it is controlled, sediment has built on the west of these headlands creating a greater degree of stability.

Within this context it may be seen that:

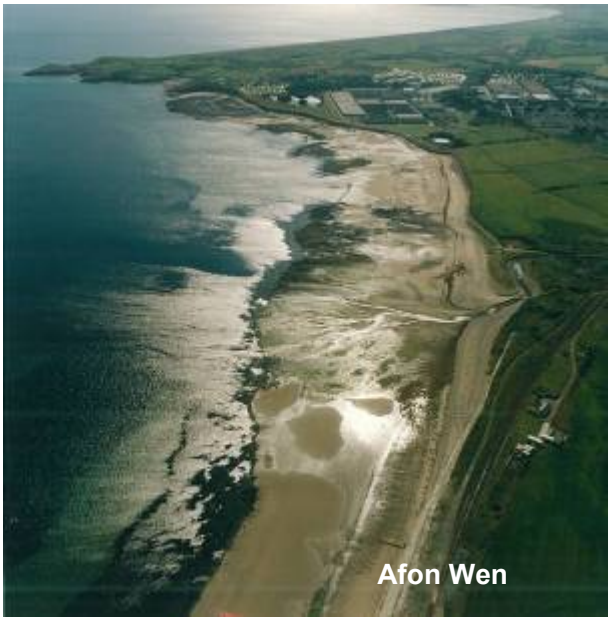
- Across the Ystumllyn, the substantial shingle ridge is held forward by the Graig Ddu headland and is relatively stable in terms of drift. Modelling of sediment movement across the frontage has indicted there is a predicted net drift to the east but that this is sensitive to degrees in terms of wave angle. In effect, the main process is one of overtopping and roll back. This applies along the whole ridge but obviously would be disrupted to a degree as the ridge rolls back exposing the hard rock outcrop of Rhiw-for-fawr.
- The east groyne and the harbour breakwater are important features in controlling this bay. There is limited drift from within the frontage but in the absence of the groyne there would be significant change with the bay wishing to step back sharply. The coast to the east of the groyne is eroding slowly, but this is not significantly affected by the retention of shingle by the groyne. The shingle would merely move beyond this natural headland contributing some additional material to the shingle ridge to the east.
- The Castle Headland is a major barrier to sediment drift and has allowed development of a relatively stable shingle beach to the west. This beach is supplied by sediment coming from erosion of the cliffs to the west. There is seen as being a significant drift along this westerly cliffed frontage. The cliffs are slowly eroding.



- The Dwyfor and the headland immediately to the east, together with the high foreshore platform all act to create a significant down drift headland. The reduced drift across the headland is compensated for by the sharp pattern of erosion to the east. The wide shingle ridge across the Dwyfor valley is relatively stable with limited easterly drift. The shingle ridges behind the back shore ridge are indicative of the progressive growth of sediment. At the westerly end the narrowing and now protected shingle bank is far more a reflection of the

interface between the rolling back of the shingle and the slow erosion of the cliffs to the west, than of significant differential drift increasing to the east.

- The clay cliffs to the east of Afon Wen are eroding back slowly.
- The defended railway frontage to the east of the Afon Wen lies well in front of the natural alignment of the shore and is subject to significant pressure with high potential drift rates to the east. This situation changes immediately as the railway track heads inland, creating the width across the mouth of the Wen for a stable shingle beach to develop. To a degree the presence of the railway defences actually help retain this beach, although this is also influenced by the fact that railway runs on slightly higher ground. The headland of Pen ychain both acts as a barrier to sediment supplied from the coast to the west and acts to provide significant shelter to the shoreline. The tendency is for this frontage to erode back to form a deeper curved bay, but this is constrained by the higher foreshore, the sections of hard rock outcrop and the defences to the Holiday Park.



With sea level rise there will be a tendency for the more stable areas of the coast to roll back and for the semi hard areas of cliff to erode at a faster rate. This increasing erosion will be exacerbated by the fact that the hard platform will be more submerged, significantly increasing energy at the backshore. One further potential factor is the protection provided to sections of the frontage by Sarn Badrig to the south. The rise in sea level will allow some increased wave energy across this feature and expose the south Llŷn shoreline, not just to the increased energy but also modifying the directional wave climate approaching the shore. This could become more pronounced with greater levels of sea level rise.

Potential Baseline Erosion Rates

A distinction is made between basic erosion of the shoreline and cliff recession, affecting the crest of the cliffs and the coastal slopes. This is noted in the table below together with other relevant factors. In assessing erosion and recession in the future, allowance has been made for sea level rise and this is discussed in Appendix C. This is also discussed briefly in following the table.

Sea level rise (SLR) will be a significant factor in future development of the shoreline, very slow erosion of the main hard headlands will still control the overall shape of the coast and they would be largely unaffected. Where there are softer cliffs or shorelines suffering erosion, the rate of erosion is likely to increase with SLR. This might be by a factor of 1.7 to 2.5 times the existing base erosion rate over the 100 years. Where there are more stable features, such as fully developed storm beaches there would be a natural roll back of the beach potentially in the order of 10m to 40m, depending on the nature of beach and the coast behind.

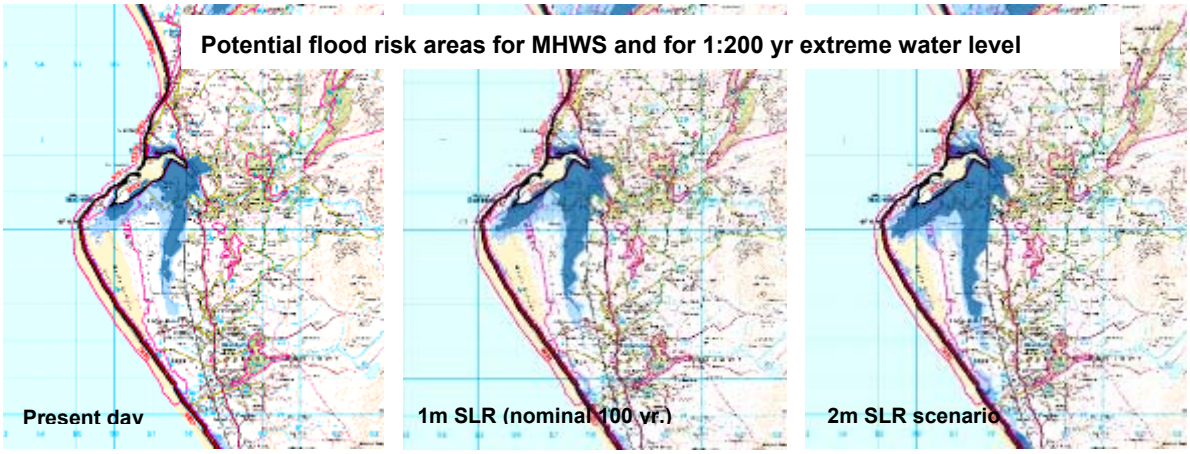
Location	NAI Base Rate (m/yr)	Notes	100yr. Erosion range (m)
Morfa Dyffryn	0.2	Tendency for roll back with SLR	30 to100
Mochras	0.2	Increased exposure with SLR	15 to 60
Llandanwg Dunes	0.2	Increased pressure due to SLR	30 to 80
Morfa Harlech	0.15	Tendency for roll back with SLR	30 to 50
Morfa Bychan	0.1	Tendency for roll back with SLR	15 to 40
Llyn Ystumllyn	0.05	Tendency for roll back with SLR	15 to 40
Criccieth east	0.3	Currently defended following failure of defences	20 to 75
Criccieth west	0.3	Eroding cliff line	10 to 75
Dwyfor	0.05	Tendency for roll back with SLR	15 to 40
Glanllynnau cliffs	0.3	Eroding cliffs	15 to 75
Afon Wen railway	0.3	Following failure of defences	35 to 100
Pen ychain east	0.3	Following failure of defence	15 to 70

Base rates have been assessed from monitoring and historical data. The range of potential erosion is assessed in terms of variation from the base rate and sensitivity in potential sea level rise. Further detail on erosion rates together with erosion maps are provided in Appendix C.

FLOODING

Potential flood risk is a significant issue across this zone, quite obviously with the several estuaries. This risk is discussed below.

Afon Artro:



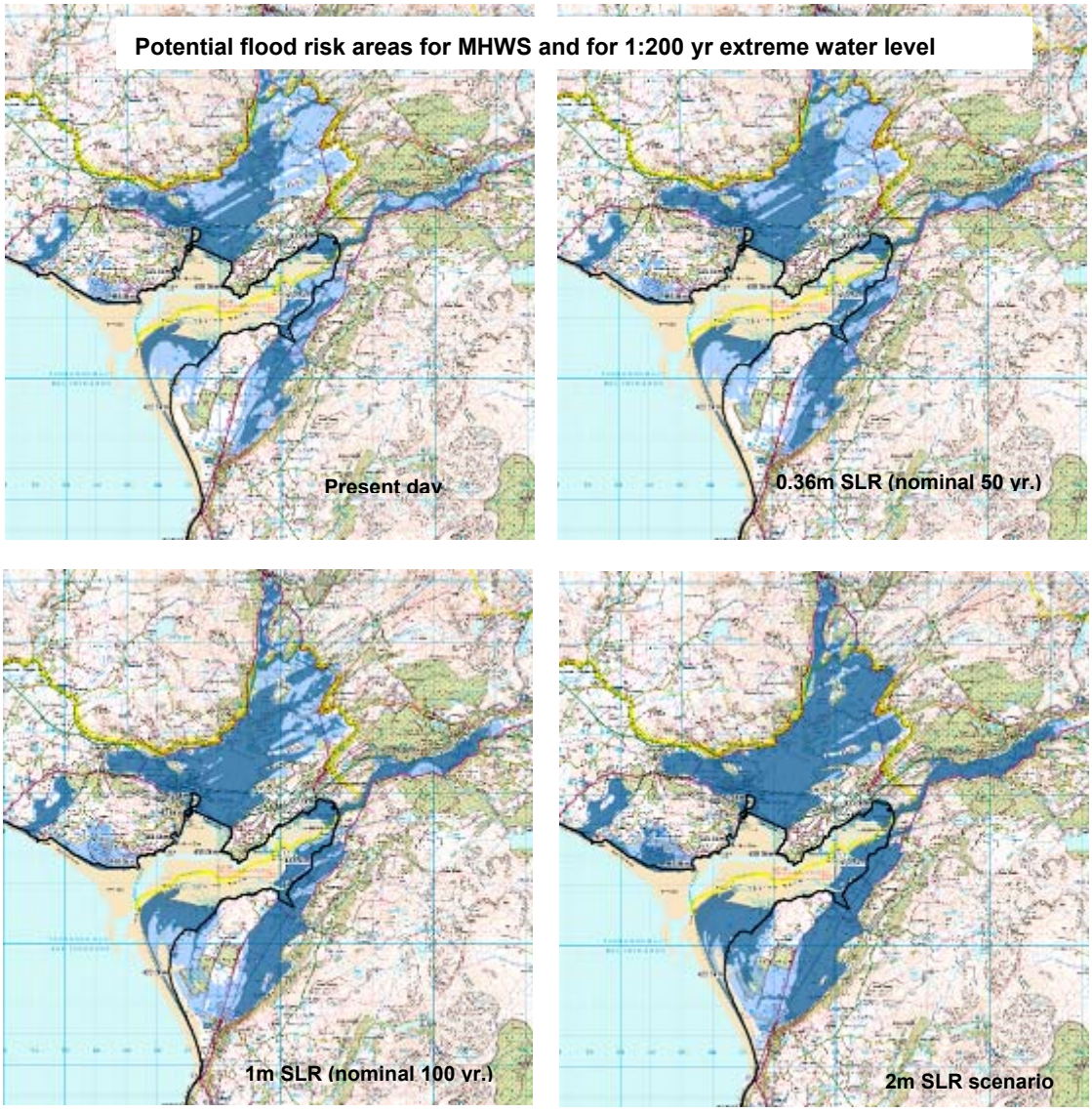
Even under normal tides there is significant flood risk to defended areas within the estuary, extending still further down the valley behind Morfa Dyffryn on more extreme water levels. It is principally along this valley that the most significant risk occurs in terms of flood risk to the properties of Morfa Mawr and to those around the access road where it cuts across this valley. There is also risk potentially, to the railway line, although this runs along an embankment, and to the main coastal road. The main area of buildings associated with the airfield are also at risk from extreme water levels.

With sea level rise, initially, the area at risk only increases marginally. The severity of consequence and the potential frequency increases such that defence to Morfa Mawr might be over topped more frequently and subsequent flooding would be more severe. With sea level rise anticipated over 100 years, the access road becomes more vulnerable and areas of the camp site in the old entrance might be subject to flooding on spring tides. Properties on the air field could also be at risk from normal tidal flooding and the railway line is potentially at greater risk. Llanbedr remains outside the typical flood risk area, as does much of Llandanwg. The main impact of sea level rise would be the increased risk within the main valley to the rear of the dunes.

Impact of different Sea Level Rise Scenarios

Under a 2m SLR scenario, the most significant increase in area of flooding is over the airfield. The majority of buildings at the northern end of the runways would now be subject to flooding on a normal spring tide. Similarly, the old church to the south of Llandanwg would be at risk. The main road north from Llanbedr would potentially be some 1.5m below normal spring tide level. Clearly, access along the shore road to Mochras would only be passable for less than half the tidal cycle.

Harlech and the Glaslyn and Dwyryd Estuary.



At present, significant areas within the Harlech valley behind Morfa Harlech are below normal spring tide level, with virtually all the of this valley being at risk from more extreme water levels. However, significantly, only a limited number of properties either at Lower Harlech, Talsarnau and Ynys being at direct risk below a 1:50 year extreme water level, these being principally at Talsarnau and Ynys. With sea level rise over the next fifty years, nearly double the number of properties in the area are at risk on more extreme water level conditions. This again rises over the 100 years with over half of the properties within Lower Harlech at risk, together with Much of Ynys and the lower part of Talsarnau. The railway and the main road would be at risk and there is the risk of

extreme event flooding from behind Morfa Harlech, between the dunes and Ynys Llanfihangel-y-traethau.

Impact of different Sea Level Rise Scenarios

Under a 2m SLR scenario, while property in Lower Harlech remains above normal spring tide level the risk of flooding from the north increases and the depth of flood to roads and railway at Talsarnau and Ynys increases.

There are already issues over sluiced drainage to the area. This will increase with sea level rise.

Within the upper Dwyryd Estuary, only limited areas beyond the main channel are at risk under normal tides, although much of the valley floor is at risk on extreme water levels greater than the 1:10 year return period. With sea level rise the area at risk on normal tides increases such that with 1m sea level rise, the whole valley floor is below normal tidal level. This might also include lengths of the main road.

A substantial part of Porthmadog is already around mean spring tide level, upstream of the embankment. This includes the school, the stations and areas of the new industrial estate. With sea level rise over the 100 years, most of the town north of the A497 would be within the normal tidal range.

Impact of different Sea Level Rise Scenarios

Under a 2m SLR scenario, there is little increase in flood extent but the depth of flooding would increase substantially. Virtually the whole valley of the Glaslyn, north of the embankment would be intertidal.

The main flood risk at Borth-y-Gest at present is from overtopping. With sea level rise, the main direct flood risk is along the valley at the eastern end of the sea front. Under the 1m sea level rise scenario the road would be at risk under normal tidal levels.

The principal risk at Morfa Bychan is at present on more extreme conditions due to breach of the dunes and spreading from the small stream to the west of the village. The extent of flooding impacts mainly on the caravan parks, with only limited risk to the village. Even with sea level rise, it is only on extreme water levels that the area would be flooded, but this would now affect areas of the main village.

Impact of different Sea Level Rise Scenarios

Under a 2m SLR scenario, the area occupied by the caravan park and the lower part of the village would be within the intertidal zone, with flood risk coming from the water courses through the area. The whole village would be at risk on extreme events.

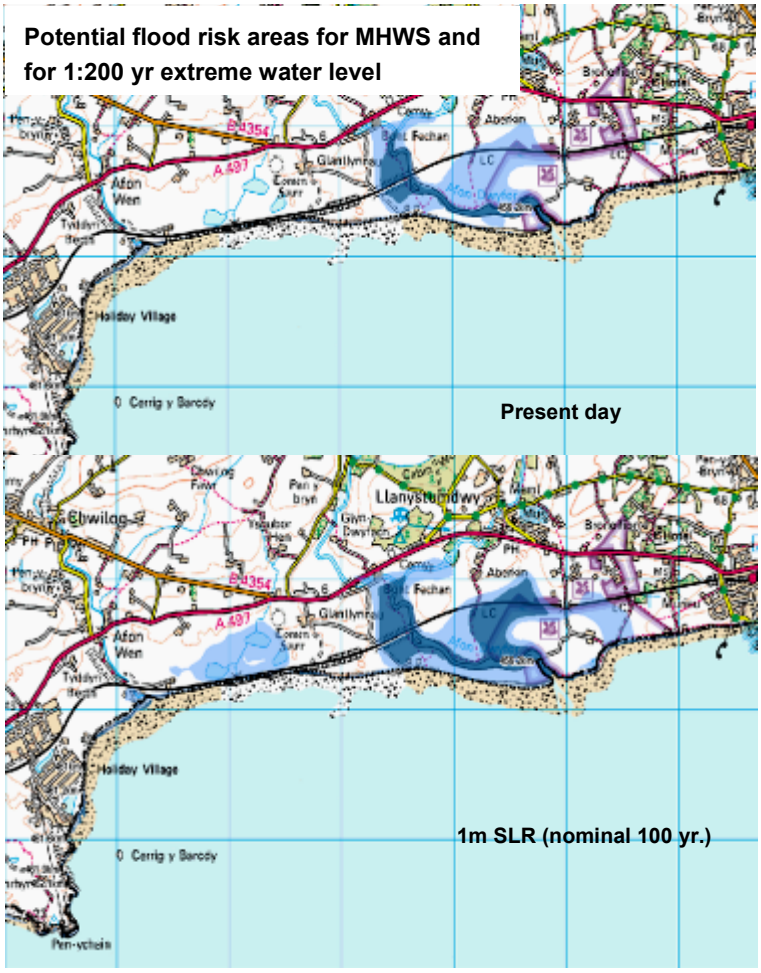
Llyn Ystumllyn is at present at risk of flooding on spring tides if the shingle bank breached. Clearly, with sea level rise, the risk of this occurring increases significantly and the depth of flood risk within the valley increases. This could impact on the railway line which runs on an embankment across the valley.

Impact of different Sea Level Rise Scenarios

Under a 2m SLR scenario, the railway line further to the west is at substantial risk of regular flooding.

Criccieth to Pen ychain.

At Criccieth, the present risk is principally that of flooding due to overtopping of the Esplanade. With sea level rise this risk increases and under a 1m sea level rise scenario there might be direct risk of flooding over the road on more extreme water levels. There is a similar situation to the west of the Castle along the lower section of Min-y-Mor.



Further to the west there is the potential for normal tidal flooding within the Dwyfor valley and more extensive flooding on extreme conditions. A greater risk occurs under the 1m sea level rise scenario with potential flooding to the railway line on spring tides. Under this scenario there would be the potential for a breach through the shingle bank at the western end of the Dwyfor valley. This would critically depend on the integrity of the shingle bank or the existing defences.

At Afon Wen, the area behind the railway line is above the 1:200 year water level at present but within the more extreme flood risk area for the 1:1000 year event. Under a 1m sea level scenario the low lying land falls within the 1:10 year flood risk area and would be intertidal under a 2m scenario. The Holiday Park would only be at risk from flooding under extreme conditions under the 2m sea level rise scenario.

EXISTING DEFENCES

There are defences at the entrance to the Artro estuary and flood defences within the estuary. The level of these defences are uncertain and run to high ground in areas, where ground levels would be less than normal tidal level under the 1m sea level rise scenario. To the north of the entrance, the defence is at present provided by dune management, but there has been discussion of constructing harder toe protection to the dune.

To the north, around the Llandanwg headland, starting in the south just north of the church, there are sections of rock revetment and then a sea wall running through to the southern end of Morfa Harlech.

There are no defences along the Morfa Harlech frontage, although there are bunds to the landfill site to the north. The principal defence to the Harlech valley is across the valley entrance at Ynys. This is then contiguous with the defence running down the

banks of the Afon y Glyn and extending behind the marshes seaward of the railway line at Talsarnau. The railway line then effectively forms the defence through to Pont Briwet.

Within the upper Dwyryd Estuary the principal defences run to the banks of the river channel protecting low lying fields.

The main defence to Porthmadog is the Cob, although there important secondary defences to the lower part of the town with the upper estuary. The main quay seaward of the Cob also maintains flood defence to the town as well as acting as a hard manmade face to the quay area.

At Borth-y-Gest there are continuous defences around the bay, with a sea wall and rock revetment. There is a further extent of rock revetment to the dunes and coastal slope within Samson Bay.

The Morfa Bychan frontage is protected principally by the dune system, although there are short sections of harder defence around the access points and slipway.

The natural shingle bank provides flood defence to the railway and to the Llyn Ystumllyn valley between Graig Ddu and Criccieth. At Criccieth there are sea walls around the harbour area and to the west of the Castle and a section of rock revetment to the toe of the cliff to the east of the headland. The breakwater to the harbour provides an important defence against waves to and to the shoreline defence in its lee.

East of Criccieth there is a section of rock revetment at the western end of the Afon Dwyfor valley. There are continuous sections of sea wall and rock revetment along the railway line between the Glanllynnau cliffs and the Afon Wen. Both the revetment to the east of the Glanllynnau cliffs and the railway defences at Afon Wen have been extended as the cliffs continue to erode.

There is a short section of sheet piled wall and revetment to the east of Pen ychain in front of the Holiday Park and sewage works.

Unconstrained Scenario

Quite obviously, the most significant influence on the central section of the zone is the Cob. In the absence of this structure, the tidal prism of the estuary system would increase dramatically. Sediment would still be drawn into the estuary and there would still be some form of dune system to north and south. However, it is probable that Morfa Harlech would not have developed as far north. The behaviour at Morfa Bychan in the absence of the cob would be uncertain.

In considering this scenario, the aim is to consider the local pressures on the coast and the potential changes that would occur under natural conditions. Given the uncertainties associated with attempting to assess system behaviour without the Cob, it is more in line with this aim if the behaviour of the natural system is considered with the Cob in place.

Along the Artro Estuary frontage, the mouth of the estuary would tend to widen, areas of flood plain would actively contribute more to the tidal prism and there would be greater flow into and out of the estuary. It seems unlikely that in this area there would be development of any major ebb bank protection to the shoreline and seem more probable that the two spits would tend to curve in more to the estuary. This would in some respects allow development of greater width and robustness in the features as the shoreline rolls back. There is also the potential for the river channel to be diverted

through the low lying land of Morfa Mawr allowing development of the dune and saltmarsh within the crook at the northern end.

Along the open coast headland of Llandanwg the coast would erode. This would provide some additional coarser sediment to Morfa Harlech and would allow some additional feed of sand as the Llandanwg dunes erode back in line with the headland. The Morfa Harlech Dunes would continue to develop as at present and would in the long term continue to roll back. The more major change in the area would be the flooding to the Harlech Valley. This would create an extensive area of saltmarsh that would gradually tend to warp up. This might be accompanied by the loss of saltmarsh to the south of the Dwyryd outer estuary as silt is drawn into the new inlet. The protected land in front of Talsarnau would convert to saltmarsh and mud and sand flats with some interesting development within the undulating surface created by the underlying ridges of rock.

The upper Dwyryd would revert to saltmarsh with some increased flow through the gorge potentially affecting the width and form of the channel in the outer estuary.

There would be erosion within the bay at Borth-y-Gest. Along the Morfa Bychan frontage the dunes would develop as at present with the dune line rolling back slowly with sea level rise.

The shingle ridges along the south Llŷn frontage would slowly roll back and the continued erosion of the cliffs would provide sediment for this to occur. The most dramatic change would occur along the Criccieth harbour frontage, where in the absence of the groyne and breakwater there would be significant retreat of the shoreline, and at the Afon Wen, where in the absence of the railway defences the cliff line would retreat creating more natural shingle beach in front of the low lying area of land.

KEY INTERACTION WITH DEFENCES

Apart from the Cob, the most significant areas of interaction between defence and the behaviour of the shoreline are:

- Along the Artro Estuary frontage and within the estuary itself. Here the management of the shoreline and the defences within the estuary are beginning to have a major impact on the system, which will become more difficult to manage into the future. The eddy pool to the back of the dunes is probably one of the most obvious symptoms of this, causing erosion of the back face of the dune and potentially encouraging this dune to breakdown and breach.
- The defence of the Harlech valley, which while not under any great pressure, if it were not there would create a very different set of conditions within the outer Dwyryd.
- At Criccieth, where the harbour breakwater and the groyne at the eastern end act to hold the current shape of the coast in a way that makes defence of the frontage more manageable and sustainable.
- At Afon Wen, where the railway defence has resulted in significant lowering of the beach.

3 Management Scenarios

3.1 No Active Intervention – Baseline Scenario 1

Over many large sections of the coast the general approach to management is for no active intervention and is similar, therefore, to the unconstrained scenario described above.

- At Mochras, the headland will continue to erode back slowly. This in turn will allow some additional sediment to flow from the Morfa Dyffryn system as this dune line rolls back. The rates of erosion are anticipated to be relatively low and while the cliff will retreat it is unlikely to impact on infrastructure over the first two epochs. During epoch three there would be need to move the track to the southern spit and the areas of the car park to the southern side of the headland would be lost. The main area of buildings on the headland would not be expected to be affected.
- At Morfa Harlech the dunes will roll back maintaining the general shape and integrity as a natural defence. This rolling back of the dunes and the rolling back of the nearshore sea bed profile will in time impact of the outfalls through the dunes: to the south draining the land behind and part way along the frontage where there is the old pump station outfall. Any attempt to intervene with this large scale process could well lead to increasing the fragility within the dune system and impact on the integrity of the dunes as a defence. Along this frontage, there is only one property at the southern end which may be lost due to erosion as the rate of erosion increases with sea level rise.
- To the northern end of Morfa Harlech and southern shore of the Dwyryd Estuary through to Ynys there is no management of the shoreline. The dunes and saltmarsh would continue to develop naturally with areas of accretion and erosion. Under this scenario there would be increasing risk of flooding across the back of the dunes. This could result in significant flood risk damage within the Harlech Valley area. This is considered further in discussion of more critical areas for management under this scenario below.
- Within the Dwyryd Gorge and the upper estuary and along the northern side of the Dwyryd Estuary through to the Cob, there are local areas of private defence to the fields within the upper estuary, over the foreshore to the south of Penrhyndeudraeth and at Portmeirion. There is only local erosion pressure and the main issues are in relation to flooding. Under this scenario, there would be increased flood risk within the upper estuary and probably failure of most of the defence in the upper estuary over epoch one and two. With sea level rise there would be a risk of flooding to the main road. Just to the north of Pont Briwet the sewage works would be lost due to regular flooding probably during epoch two as more regular overtopping resulted in failure of defences. There would be damage and eventual loss of the properties of Craig-y-don and Ynys-fawr. There might also be some damage to the seafront at Portmeirion.
- Under this scenario the dunes of Morfa Bychan would be allowed to adapt naturally, rolling back with sea level rise. The risk to this area does not come from the erosion of the dunes as much as from widespread flooding to the area behind the dunes discussed earlier. This would have a significant impact on the area and on the sustainability of the village. Due to the intense use of the beach, there is concern that without management this will damage the dunes and that this would exacerbate the flood risk issue. There is also significant risk from tidal flooding from the water courses. In the long term under this scenario there could be such significant risk that the village would be abandoned.
- Between Graig Ddu and Criccieth the shingle bank will roll back and with sea level rise tend to suffer greater overtopping. The roll back of the ridge would impact on the railway line not just in terms of flood and erosion but in terms of the track being

submerged in shingle. Within the valley the railway line may with sea level rise be subject to regular flooding. Under this scenario, over epoch 3, it is unlikely that the railway would be able to function, and potentially this could occur during epoch two under increased rates of sea level rise. This would have significant consequence for Criccieth and Pwllheli. Management of this risk is also linked to the risk at Afon Wen and Abererch and to risks associated with the line further south along the coast.

- To the west of Criccieth, much of the coast is unmanaged and would continue to erode or roll back. This would result in the loss of properties along the Y Dryll frontage potentially over the next twenty years but almost certainly during epoch two. This frontage provides important sediment to the defences to the east at Criccieth. One of the properties and areas of the Afon Dwyfor valley lies within land managed by the National Trust. The National Trusts policy is to allow natural change at the shoreline. The Afon Dwyfor valley would be subject to increasing flood risk and this could result in regular flood risk to the railway by the end of epoch two. The defence at Ty'n-y-morfa would eventually fail due to overtopping and loss of integrity of the revetment. Due to the fact that this defence would have prevented natural development of the shingle ridge and because the defence would be in advance of the natural shore line such a loss could be quite sudden, and there is the potential for a breach through to the Dwyfor. It is uncertain whether this would be sustained as a new entrance channel to the river, but this is a possibility. The existing track to the property may be lost earlier. At Afon Wen, the defences to the railway line would fail due to reducing beach level and as a result of damage due to overtopping. Various works have been undertaken to the frontage and future works are under consideration at present. When defences fail there would be sudden and rapid erosion with the loss of the railway line. The improved defences to the Holiday Park to the east of Pen ychain would act to prevent erosion possibly through towards the end of epoch 2. Failure of the defences would then result in erosion which over epoch three, which would result in loss of local areas of the park and the sewage works.

The above provides a general overview issues under this scenario. Other more high risk areas are discussed below.

Artro Estuary.

Under this scenario no further works would be undertaken in terms of managing the shoreline, the headland to the north of Llandanwg or defences within the estuary. Defence to the main headland could fail over epoch 2 without maintenance. This would result in loss of the railway and loss of property. This would also have the longer term impact of reducing the width of beach area to the south. However, possibly earlier than this the erosion at the back of the Llandanwg dunes, together with continued pressure on the front face of the dunes may well result in a breach over epoch one. Whether this would result in a new entrance channel being formed is uncertain but in all probability the breach would result in regular over wash of the underlying harder ridge and would significantly alter the behaviour within the estuary. There would be impacts on navigation and on moorings and the sailing club is likely to be lost. There may be increased sand imported and this could help sustain the dunes around the north curve of the estuary. The defence to southern spit may last into epoch two but would then fail and this would have the potential to create a further area of overwash, further disrupting the use of the estuary.

As these seafront defences failed so would, eventually, the flood defences to Morfa Mawr. These defences would be more regularly overtopped and would fall into disrepair. There would be gradual failure of other flood defence within the wider area and this

would open the valley behind Morfa Dyffryn to tidal inundation. There could be significant opportunity for recreation of saline habitat, potential addressing the issue of squeeze that will probably occur around the fringe of the existing estuary with sea level rise. There would, however, be flooding to several properties and probable loss of the main road and loss of the railway line. Access to the airfield would become tidal and there would be flood risk to existing buildings to the airfield. Any opportunity for developing the potential of the airfield would be lost. The loss of the main road and railway line would have serious consequences in terms of communities within the area.

One potential advantage, over and above the important benefits this scenario brings to nature conservation values, could be the opportunity to re-establish a more naturally functioning estuary with the main channel developing across Morfa Mawr and through the entrance channel. This could lessen the pressure on the inside of the northern dune system and if this dune had not already breached this would have given scope for more sustainable management of the open coast area.

Harlech Valley and Talsarnau
Under this scenario defences to the valley and along the Talsarnau marshes would be allowed to fail. The tidal sluices would be allowed to fall into disrepair. This could occur over epoch 1. The most immediate impact would be the loss of the railway due to regular flooding and this together with the loss of the road, coupled to the loss of these features to the south, as discussed above would in effect isolate Harlech and the surrounding communities. Irrespective of this there would also be significant flood risk over epoch two and epoch three to Lower Harlech. This would initially be on more extreme events but the frequency of flooding would increase. While the main areas of the Golf Course would not be at direct risk of flooding until epoch three, there would be little scope for water level management to the area and this would have significant consequence of the status and economic viability of this important resource to the area.

Allowing flooding to the Harlech Valley would create potential significant benefit in terms of creation of saltmarsh and this has the potential to compensate for possible loss of such habitat due to squeeze in the main estuary area. Even so, the social and economic losses and impacts of this scenario would be substantial, arguably, given among other issues including the impact on the World Heritage Site; these impacts would certainly be both regional and national.

At Talsarnau, there would be substantial flood damage to a significant part of the village, despite the fact that the village sits upon one of two ridges of high ground running in a southwesterly direction through the area. The railway through this area is at flood risk but less significantly so than in the Harlech Valley. Even so the railway in this area would be lost if defences where abandoned.

Porthmadog
Under a No Active Intervention scenario, there would be no action to improve flood defence to the low lying area of the town. There would be significant food risk to properties and to infrastructure. Even if the tidal sluice at the Cob was still operated under this scenario in the short term, there would still be an on-going risk due to tidal locking of fluvial flows. Over time, under this scenario the sluices would fall into disrepair, opening the area to direct tidal flooding on extreme events. With sea level rise this risk would increase, with large areas of the town at present below MHWS. Potential damages assessed by the Catchment Flood Management Plan are for losses amounting to some £15M to £18M in the future; this based on fluvial flood risk. By comparison, the

SMP2 assessment of damages that might arise from direct tidal flooding are of the order of £430M over the 100 years.

Under this scenario much of the more recent inward investment into the area would be lost. Future opportunity for regeneration and developing Porthmadog as a core Hub for North West Wales would also be lost.

There would be significant opportunity for re-creation of coastal habitat within the upper Glaslyn Estuary. This could enhance and support aspects of the Pen Llŷn a`r Sarnau/ **Llŷn Peninsula** and the Sarnau SAC. It would, however, potentially detrimental impact on features of the Coedydd Derw a Safleoedd Ystlumod Meirion/ Meirionnydd Oakwoods and Bat Sites SAC.

Over time the Cob may fail. Even without maintenance, this might not actually occur until well into epoch 3. This would eventually open the old area of the estuary and restore some natural function of the much larger system. The way in which the system would behave is uncertain. There have been several changes that have arisen from the enclosure by the Cob, such as the increased accretion in the area. Opening up the estuary due to the failure of the Cob, would not, therefore, just be a case of the estuary returning to the way in behaved prior to the construction of the embankment.

Criccieth.
Under this scenario, the eastern groyne would fail, probably in epoch 1. There would be significant loss of sediment in front of the Esplanade. The Harbour breakwater would potentially fail, possibly towards the end of epoch 2, as it came under heavier wave action. During epoch 2 and through epoch 3, the defences around the harbour would fail and there would be significant erosion as the whole section of coast adjusts back to a more classic bay shape. It is difficult to assess with accuracy the rate of erosion as this is an area which has been defended for some time. However, putting the timing of such erosion to one side, the extent of erosion before any form of stability was established would quite probably mean the loss of all areas back to the railway line. This would mean that the main seafront of Criccieth would be lost.

On the western side of the Castel Headland, the loss of defences would mean the potential loss of property back to Stanley Road

In both areas the coast would be eroding to higher ground, creating a significant cliff between the town and the beach. In addition, therefore, to the significant direct economic damages, these patterns of erosion would in effect remove any opportunity to develop a new seafront. The whole character and an important value of the town would be lost.

This scenario highlights for the whole zone the significant loss that would occur to the overall economic structure and infrastructure of the area. The impact would be that the opportunity for this area to function as a central hub for development of North West Wales would be lost, that the existing communities would be severely affected; to the extent that the integrity of existing communities would be put at risk, and than the essential transport network would be totally disrupted. Against this, the scenario has identified important areas where any scope for opening areas to flooding or more natural change in terms of physical processes, could have important nature conservation benefits, and in some area important benefit in allowing natural defence to perform naturally.

An assessment of economic damages and potential broader impacts of this scenario are summaries in comparison to the With Present Management scenario, which is discussed below.

3.2 With Present Management – Baseline Scenario 2

Table below sets out the present management policies under SMP1.

SMP 1 No.	Unit	Policy	Subsequent Management Approach
Gwynedd			
6.1	Shell Island	DN	
6.2	Llananwg	HTL	
6.3	Harlech	DN	
7.1	Talsarnau	DN	
7.2	Port Merion	DN	
7.3	Porthmadog Cob	HTL	
7.4	Blackrock sands	HTL	
8.1	Criccieth Shingle Bank	HTL	
8.2	Criccieth	HTL	
8.3	Y Dryll	DN	
8.4	West Afon Dwyfor	DN	
8.5	Afon Wen	HTL	

The following information and policy is abstracted from the North West Wales CFMP Draft Plan. The area is covered by four CFMP policy units.

Policy Unit 3 covers the area to the west of Criccieth, although not specifically addressing issues at the Afon Wen or Afon Dwyfor. The general policy for this unit is:

Policy selected	**Policy 2 -** Reduce existing flood risk management actions (accepting that flood risk will increase over time). Note: this policy option involves a strategic increase in flooding in allocated areas, but is not intended to adversely affect the risk to individual properties.

Policy Unit 5 covers the coastal area between Criccieth and Porthmadog. There are no rivers specifically relating the management of the shoreline identified or discussed in the CFMP. The general policy for this unit is:

Policy selected	**Policy 3 -** Continue with existing or alternative actions to manage flood risk at the current level.

Policy Unit 6 covers, quite specifically, the area of Porthmadog and, although reference is made to tidal locking due to the Cob, the CFMP does not consider the direct response to tidal flooding and sea level rise. The general policy for this unit is:

Policy selected	**Policy 5** - Take further action to reduce flood risk.

This recognises the significant risk at present to the town and the need for improvement in defence.

Policy Unit 7 covers the coastal area of the Dwyryd and the Artro. There are no rivers specifically relating the management of the shoreline. The general policy for this unit is:

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Policy selected	**Policy 3 -** Continue with existing or alternative actions to manage flood risk at the current level

The CFMP for this unit identified that: “the flood zone modelling only showed a small increase in flood risk across the coastal lowlands, however further studies on the tidal affects from sea level rise will need to be carried out in more detail to assess the actual risk”.

The focus of both SMP1 and the CFMP is to maintain and improve defence to the main area of development around Porthmadog but for a more adaptive approach to be taken elsewhere. The SMP 1 policies for Do Nothing for areas such as Harlech and Talsarnau, was based on considering only the coastal areas, rather than the potential for flooding to the valley behind. Since there was considered to be no works required to manage the dunes, the sections of rock cliffs and the saltmarsh over the next fifty years, the policy of Do Nothing was developed. The clear intent, however, was that the settlements were important and flood risk management to these areas was assumed. This is the intent of management that is considered under this baseline scenario. This SMP2 scenario, taking this approach forward over the next 100 years, is therefore based on the intent to defend these areas.

SMP 1 did not consider the estuary areas of the Artro or the upper section of the Dwyryd. These sections of the coastal area are given a policy 3 under the CFMP. It is therefore taken that the intent is to continue to manage defences within these areas. Since it would not be technically feasible to do so without raising the height of defences this is taken as this With Present Management scenario.

Morfa Bychan, or Blackrock Sands, is given an SMP1 policy of Hold the Line. This assumed that the dunes if managed naturally would provide adequate protection to the holiday parks and properties behind. The intent taken forward under With Present Management is that the risk to these areas is to be managed in such a manner that the Holiday Park and village are sustained. To the east of Criccieth the SMP1 policy is for Hold the Line. This is identified within the SMP1 as being a policy of management and reprofiling the shingle bank to mange the risk to the railway line. At Criccieth the scenario is for management of the existing defences and at Afon Wen, the main justification and approach considered within SMP1 was for continued linear defence to the railway line.

This, therefore, defines the approaches to management taken forward over the 100 year period of the SMP. The issues around this are discussed below. To reflect the slightly different issues under this scenario, and the higher degree of interdependency between areas, the sections of coast are divided more broadly than in baseline scenario 1.

Mochras and the Artro Estuary.
Over the headland and much of the natural cliff through to the root of the southern spit to the estuary the approach is to allow continued erosion. This is as base line scenario 1 for No Active Intervention and is described above. The policy for Hold the Line is for the existing section of defence and defence around the spit. The frontage is under no great pressure to erode and technically the defences could be retained although there would be the need to reinforce the defence with sea level rise and increased exposure. While

technically achievable, this would not address the flood risk to the spit. Furthermore, while this defences acts to maintain the use of the estuary, there is little direct economic benefit in doing so. It is only when considering the broader intent of managing use in the area that there is potentially benefit in managing this length.

Along the northern section of the frontage, there have been several and on-going attempts to maintain the functioning dune system. To actually hold the line of defence as at present, this would require increasing control. Sand fencing as undertaken at the moment does not address the underlying vulnerability of the dunes to erosion. The typical response to this would be to harden the frontage with sections of rock revetment. It is unlikely that this could be justified, even if it were desirable. This with sea level rise will require further effort in the future such that, potentially over epoch 2, the important natural value of the dunes would be lost.

One important aspect of management of this section is the risk of erosion on the inner face. This erosion seems to have come about as a result of the unnatural shape of the estuary. Continuing to manage this is likely to lead to harder defence on the inside and in the future the dune spit would, in effect become a rock breakwater. While this would sustain current use of the estuary for moorings, the cost and impact of progressively hardening the defence to the shoreline is unlikely to be acceptable or sustainable.

Part of the issues with management of the estuary is the constraint imposed by the access road and the flood defences. Holding the Line would maintain defence to the railway and the main road, it would also ensure access to the airfield. However, there would be squeeze of the natural marsh in front of defences; with no scope for mitigating such lost of internationally designated habitat. There would be increasing need to raise the defence and this would require not just raising but also substantial increase in width of the embankments. Key elements of use of the area, such as the access road, the potential redevelopment of the airfield and even the boat use of the estuary would be increasingly dependent on defences. These defences would further constrain the natural development of the area building pressure into the management of the whole area. This is not considered sustainable.

Irrespective of this, but linked to possible management options for the frontage, the continued management and defence of the headland at Llandanwg is considered important in maintaining the transport route along the coast. This headland is currently defended and even with sea level rise to continue to defend this frontage is considered achievable. There are significant benefits in doing this in terms of properties at risk, the road and the railway. Continuing to hold this frontage does provide important control in terms of managing the entrance to the Artro Estuary. Holding this cliff line is not seen as having a significant impact on the dunes to the north

Harlech Dunes and Harlech Valley.
The management of the dunes under this scenario is for No Active Intervention. The natural dunes would provide a competent defence to the area behind. To attempt to intervene, even over a short length, is likely to start a process where there would be greater and greater need to intervene. This With Present Management approach is seen as being sensible and sustainable in terms of meeting nature conservation values and maintaining defence to the hinterland.

The main defence of the valley is across the northern end of the valley at Ynys. This defence is very sheltered and on a generally accreting area of marsh. It is suggested that one of the main problems has been this accretion, with increasing difficulty in

maintain drainage through gravity sluices. With sea level rise this problem would increase. Quite possibly, therefore, over epoch 2, to continue to maintain appropriate standards of defence this system may have to be pumped or potentially larger areas of land have to be opened to provide storage over high water periods.

In Holding the Line, the scenario would maintain risk management to properties in Lower Harlech. Much of the property is above normal tidal levels even under a 2m sea level rise scenario. Overall the benefits of maintaining defence to the area are strong economically and over the 100 year period sustainable. One area of risk is from more extreme event flooding from directly behind Morfa Harlech. The main flood pathway lies outside the internationally designated SAC boundary although on extern events under higher sea level rise, to defend from any flood risk through to the main valley would require flood management within the SAC boundary. Therefore, an absolute policy intent to defend all this area beyond the 100 years of the SMP2 has to be called into question.

In defending the valley, there may also be long term impacts on habitat within the Dwyryd estuary to the north. Defence of the valley would reduce opportunity to address this.

Talsarnau.
Holding the line of the longer Talsarnau frontage introduces the same issues with respect to habitat as identified above. The defence of the frontage extends some 3km from the Afon Glyn through to Y Garth. Although the SMP 1 suggested that the only significant asset was the railway line, the re-assessment, taking into account sea level rise, now indicates that significant areas of Talsarnau would be at risk. Economically there could be justification for continuing to defend the frontage. However, potentially toward the end of epoch 1, this would require significant improvements to be made to the defences. Even this might be justified but as sea level rises still further the ability to maintain these banks has to be questioned in terms of sustainability. The present defences have been constructed, typically, along the lowest lying areas of land, presumably attempting to take maximum advantage in terms of reclamation. This means that in places these defences are already raised in excess of 1m just to match the level of land behind that they are defending. This might be quite critical in terms of the technical sustainability of the defences in the future.

Upper Dwyryd
The sustainability of maintaining these defences under this scenario would be very questionable in the long term. While holding the line within this area does also provide defence to the main road, this could be achieved more directly to the edge of the flood plain. Maintaining defences at their existing level would mean that they would be far more frequently over topped in the future, this would cause their failure. To raise defences in line with sea level rise would require increasing both the height and the width of the defence. The use of the land behind would be difficult to drain and would become very vulnerable to sudden failure during extreme events. There would be damage to areas and features of the SAC. This scenario, of attempting to maintain defences in this area, would not really benefit the agricultural interests because of the increasing cost of drainage and maintenance; neither would it meet environmental designations. This scenario is not seen as being sustainable.

Porthmadog.
Even with sea level rise it is technically and economically feasible to maintain the Cob and to defend Porthmadog. There would, under this scenario, be a need to raise defences along the initial section of wharf within the harbour and potentially to areas just

downstream of the sluices. Given the very high economic damages that might otherwise occur and the very uncertain impacts not continuing to manage the Cob would have on the whole area, this approach is seen as appropriate. This does, however, raise issues in the long term of future sustainability to lower areas of the town. This would need to be considered for the long term.

The continued defence at Borth-y-Gest would require significant raising of the front defences and further possible defence along the valley at the eastern end of the village. This scenario would sustain the village and the benefits go beyond that of the properties at flood risk. The most vulnerable sections of the road provide the access to much of the village and as such defence of these areas would be essential to maintaining values within the village. There would however, be significant landscape issues over the longer term as defences have to be raised. The area becomes more critically dependent on defences to maintaining access and emergency response. The character and safety of the community is put at risk under this scenario.

Impact of different Sea Level Rise Scenarios

Under a 2m sea level rise scenario defence levels would have to be raised on the main seafront by an equivalent amount. Potentially the road could be some 2m below normal high tides. There is a substantial risk that the village could be isolated during an extreme event

Morfa Bychan.

Over epochs one and two the basic approach to With Present Management would be to maintain the dunes as a natural defence to reduce flood risk behind. In epoch three, while under this approach the dunes would still provide the front line of defence, there would be increased flood risk to the Holiday Parks and to the village from the water courses through the area. Without improving defences there would still be significant flood damage to areas of the village.

Impact of different Sea Level Rise Scenarios

Under a 2m sea level rise scenario The regular flooding to areas of the Holiday Park and village would increase such that much of the Holiday Park and lower lying areas of the village would be below normal spring tide levels.

Clearly the way in which this area is managed into the future would depend critically on the rate of sea level rise. If the intent is to Hold the Line in such a manner as to not increase flood risk, then there would be a need to construct new defences behind the dunes. This might be economically sensible from the perspective of the Holiday Parks but is unlikely to attract grant in aid. The risk is a growing dependency on flood defence and that future development of the area would be based on this assumption of continued defence. This approach tending towards more fixed risk management in to the future, beyond the period of the SMP2 is unlikely to be considered sustainable.

Criccieth East and Eastern Shingle Banks.

To the east of Criccieth, SMP 1 policy is for Hold the Line with the intent to manage the shingle ridges through reprofiling. At present all indications are that the shingle banks are relatively robust and of sufficient bulk to sustain this approach in the short term. However, experience has shown on the Suffolk and Norfolk coasts that such an approach can only be sustained so far before the natural ability of the shingle banks to provide a defence is compromised. Typically within epoch 2, holding the shingle banks forward, reprofiling and building the banks higher to address sea level rise will increase the banks vulnerability to breaching. This would be likely to result in closure of the

railway over a period of time while the shingle overwash is removed from the track and the banks regraded. As this occurrence becomes more frequent, the natural response would be to start replacing the shingle bank with rock armour. Under this With Present Management scenario, this is likely to be in a responsive manner and the longer term impact would be in extending the defence progressively over the whole frontage. Although shingle recharge might mitigate this to some degree, the basic concern that the shoreline was still being held forward too far, as a linear defence, would be an issue in retaining sediment.

A key issue in terms of the need for management is the level and integrity of the railway embankment behind the ridge. In this, the frontage might be considered in three sections. To the west, it is understood that the railway is on a low embankment below and behind the shingle ridge. As the ridge rolls back, the railway embankment would need to incorporate the ridge and hard defence would need to be put in place. This would have a significant impact on the nature conservation values of the area. The shingle ridge falls within the SAC designation.

Over the Rhiw-for-fawr frontage, the railway and shingle ridge are backed by and actually cut into the hard rock out crop of the headland. The natural process here would be for this promontory to emerge at the shoreline as the shingle rolls back. Under the With Present Management scenario the defence of the railway line would be merely reinforcing the natural division of the coast. This would, as it would naturally, form a new headland at the shoreline.

Across the Llyn Ystumllyn valley, the railway line runs some way back from the shingle ridge. Holding the line of the ridge further west in this section would tend to result in a progressive defence of the whole length, despite the fact that the railway line is at less direct risk. Critical to the need for this would be the actual level of the railway embankment.

This scenario for holding the line is seen as being fraught with potential difficulties in maintaining the defence to the railway line. The suggested approach of SMP1 is likely to be sustainable in the short and even possibly medium term, but is likely to result in an increasing fragile defence system protecting the important regional asset of the railway.

There is some clear interaction between the Criccieth Frontage and that of the railway. This is more in terms of the long term geomorphological development rather than one of direct sediment supply. The east groyne at Criccieth does retain sediment on its western side, but this is relatively small in comparison with the volume of shingle to the east. More significant is the way that, as structures or headlands emerge and take greater prominence in the future, as the natural coast rolls back, so a potential series of interrelated bays might start to develop.

The With Present Management scenario for the Criccieth frontage is for Hold the Line. This would imply maintaining and, as identified in SMP 1, increasing toe protection to the sea walls. The eastern end of the town frontage would become the most prominent point in the frontage and require most protection. The approach to strengthening the defences in this way is certainly seen as being sustainable and worthwhile over the short to medium term. The more difficult issues arise in the long term. As sea level rises while there would not be direct flooding of the frontage apart from under more extreme events, the degree of overtopping would be a very significant issue. To ensure the integrity of the defence and to avoid regular damage to areas behind, the typical approach under this scenario would be for construction of a significant rock revetment.

The general long term impact on the area would be a significant reduction in amenity value to the sea front, to the extent that in the long term this Hold the Line policy may actually be critically detrimental to the very values and characteristics that the defences are intending to protect.

Criccieth West to Pen ychain
The two areas of current defence are at Criccieth west and at Afon Wen, including the Plus Glanllynnau and Holiday Park rock revetments, these areas under this scenario have policies for Hold the Line.

In term of Criccieth West the defence here is critical to defence of a significant area of property and access to the Castle. Over time defence of this area will require further strengthening but the defences here are such that to do so will not significantly impact on the amenity of the frontage. Maintaining the sediment supply from the west will be important and this would be compatible with the With Present Management policy of No Active Intervention to the cliffs to the west.

The management across the Dwyfor frontage would be the same as under scenario 1. To attempt to sustain defence to the current length of protection to the west of the Dwyfor would start to introduce pressures in terms of management that would be seen in the longer term as being unsustainable. This as identified in scenario 1 does call into question the defence of the railway through the Dwyfor valley.

Over the Afon Wen frontage, there are two main issues with continuing a policy of defence. The first is that the current linear defence to the railway line is already under significant pressure. Even without sea level rise there has been a long term process of erosion of the foreshore platform and this has required significant works to strengthen defences. With sea level rise this pressure will increase. The other issue has been that as the natural cliffs to the east, the Glanllynnau cliffs erode, so there has been a need to extend defence of the railway to the east. This does not address one of the key principles in terms of management of the area that reliance on defence should be reduced. It also starts to impact significantly on the geological education and research value of the designated cliff line, while also potentially removing important sediment from the system.

The importance of the railway line is recognised, but to maintain the current alignment of the track through the whole of this area starts to impose significant issues for management into the future.

An assessment of economic damages and potential broader impacts of this scenario are summarised in comparison to the No Active Intervention scenario in the subsequent tables.

4 Summary Comparison and Assessment of Baseline scenarios.

Table 1 compares the economic damages that might arise under the two baseline scenarios. Table 2 provides a summary comparison in terms of the overall objectives based on the key issues identified in the introduction to this Coastal Area.

Erosion damages and those associated with flooding are identified separately in Table 1. The aim of this table is to demonstrate the potential economic damage that might arise from either flooding or erosion. As such properties that might be lost in the future due to erosion are not discounted from the assessment of flooding. Similarly, properties whose value may have been written off due to regular flood damage are still included within the assessment of erosion. Such an approach is clearly not strictly in line with normal economic appraisal at strategy or scheme level. It is however, considered appropriate at the higher level of the SMP assessment where the essential aim is in identifying potential different forms of risk in assessing different scenarios. Where this is felt to disproportionately distort the economic assessment then this is identified in appendix H and the economic case adjusted accordingly.

The assessment of economic damage is made using a simplified Modelling Decision Support Framework (MDSF). In the case of erosion, this GIS based tool takes the predicted erosion distance for any section of the coast based on the assessment of erosion by the end of each epoch. It is then taken that there would be a linear erosion rate between these timelines (e.g. a property located midway between the epoch 1 timeline (20 years) and that for epoch 2 (50 years) would be taken as being loss in 35 years). Each property is defined by a single point rather than by its full footprint. No account is taken in the assessment of loss of access or loss of services, although this is discussed in the text where critical. The MDSF method then draws information from a property data base, providing general information with respect to that property. The value of the property is discounted in terms of when that property may be lost.

In the case of flooding, the open coast water levels are assessed against threshold levels for individual properties based again on the property point source data base. No detailed modelling has been undertaken to assess flow paths and or possible increase in water levels dues to estuary processes. It is taken that, when a flood defence fails or is overtopped, the whole flood area behind a defence is open to flooding and that flooding would occur to the full extent of the potential flood plain, over a single high water period. Damages are assessed in relation to the depth of flooding that would occur based on the type of property identified in the data base. From this assessment of potential flood damage for any specific water level condition, annual average flood damages are determined during each epoch. An average annual average damage value is taken between the present (2010) and 50 years time (2060) and between 2060 and 2110. This average value is taken in determining an estimate of discounted Present Value (PV) Damages over the period of the SMP. This simplified approach allows consideration of flood risk under different sea level rise predictions for different scenarios.

Table 1. Economic Assessment

The following table provides a brief summary of erosion damages determined by the SMP2 MDSF analysis for the whole PDZ. Further details are provided in Appendix H. Where further, more detailed information is provided by studies, this is highlighted. The table aims to provide an initial high level assessment of potential damages occurring under the two baseline scenarios.

ASSESSMENT OF EROSION DAMAGES

Epoch	0 -20 year			20 – 50 years			50 – 100 years			50 – 100 years (2m SLR)		
No Active Intervention	**No. of properties:**		**Value**	**No. of properties:**		**Value**	**No. of properties:**		**Value**	**No. of properties**		**PV Damages**
Location	*Res.*	*Com.*	**x £k**	*Res.*	*Com.*	**x £k**	*Res.*	*Com.*	**x £k**	*Res.*	*Com.*	**(£x1000)**
Llandanwg	0	0	0	0	0	0	7	0	1195	7	0	147
Penrhyndeudraeth	0	0	0	1	0	212	0	0	0	1	0	78
Porthmadog	2	0	216	12	2	1565	87	5	10,311	109	7	1,686
Criccieth East	0	0	0	5	1	577	26	9	3,598	33	13	627
Criccieth West	0	0	0	17	8	1,987	35	3	4,250	67	12	1,266
Y Dryll	0	0	0	0	0	0	2	0	161	2	0	25
Pen ychain	0	0	0	0	0	0	0	0	0	1	1	0
											Total for PDZ1	**3,830**
With Present Management	**No. of properties**		**Value**	**No. of properties**		**Value**	**No. of properties**		**Value**	**No. of properties**		**PV Damages**
Location	*Res.*	*Com.*	**x £k**	*Res.*	*Com.*	**x £k**	*Res.*	*Com.*	**x £k**	*Res.*	*Com.*	**(£x1000)**
Llandanwg	0	0	0	0	0	0	1	0	108	0	0	13
Penrhyndeudraeth	0	0	0	1	0	212	0	0	0	1	0	78
Porthmadog	2	0	216	0	0	0	2	0	320	0	0	237
Criccieth East	0	0	0	0	0	0	0	0	0	0	0	0
Criccieth West	0	0	0	0	0	0	0	0	0	0	0	0
Y Dryll	0	0	0	0	0	0	2	0	161	2	0	25
Pen ychain	0	0	0	0	0	0	0	0	0	0	0	0
											Total for PDZ1	**355**
Notes: PVD determined for 1m SLR in 100 yrs.												
Other information:												

The following flood damages have been determined through use of MDSF. These figures are aimed to indicate the level and impact of flood risk rather than being a detailed economic appraisal. In many areas substantial numbers of properties would be liable to flooding on the more frequent events both under NAI and WPM, a nominal write off value has been allowed in the table for properties at frequent risk; this generally excludes values at risk at present on a 1:1 year event, in 50 years time for the 1:10 year event and in 100 year time the 1:50 year event.

ASSESSMENT OF POTENTIAL FLOOD RISK

	Flood risk tidal 2010			Flood risk tidal 2060			Flood risk tidal 2110			tidal risk 2m SLR		
No Active Intervention	**No. of properties**		**AAD**	**No. of properties**		**AAD**	**No. of properties**		**AAD**	**No. of properties**		**PVD**
Location	<1:10 yr.	>1:10 yr	**x £k**	<1:10 yr.	>1:10 yr	**x £k**	<1:10 yr.	>1:10 yr	**x £k**	<1:10 yr.	>1:10 yr	**(£x1000)**
Llanbedr and Airfield	0	7	223	0	7	30	0	9	37	0	13	4409
Llandanwg	0	15	5	0	17	7	0	27	74	0	53	383
Morfa Harlech	0	151	197	0	288	285	0	430	3326	460	42	16449
Afon Dwyryd	0	8	5	0	8	26	0	12	38	12	3	434
Porthmadog	0	1240	7193	0	1278	7844	0	1323	74286	0	1379	430826
Borth y Gest	0	9	2	0	11	8	0	19	46	0	33	239
Morfa Bychan	0	116	16	0	211	151	0	308	737	326	6	3867
South Lleyn Coast	0	1	0.02	0	4	1	0	8	14	1	11	48
											Total for PDZ12	456654

	No. of properties		AAD	No. of properties		AAD	No. of properties		AAD	No. of properties		PVD
With Present Management												
Location	<1:10 yr.	>1:10 yr	**x £k**	<1:10 yr.	>1:10 yr	**x £k**	<1:10 yr.	>1:10 yr	**x £k**	<1:10 yr.	>1:10 yr	**(£x1000)**
Llanbedr and Airfield	0	7	6	0	7	30	0	9	37	0	13	475
Llandanwg	0	15	3	0	17	7	0	27	9	0	53	179
Morfa Harlech	0	151	27	0	288	38	0	430	122	0	502	1201
Afon Dwyryd	0	8	5	0	8	26	0	12	38	0	15	443
Porthmadog	0	1240	329	0	1278	350	0	1323	382	0	1379	10182
Borth y Gest	0	9	2	0	11	4	0	19	10	0	33	93
Morfa Bychan	0	116	16	0	211	151	0	308	737	0	332	3896
South Lleyn Coast	0	1	0.02	0	4	1	0	8	8	0	12	31
											Total for PDZ12	16588

Table 2. General Assessment of Objectives

The following table provides an overall assessment of how the two baseline scenarios impact upon the overall objectives. Specific objectives are set out in more detail within Appendix E. The table aims to provide an initial high level assessment of the two baseline scenarios, highlighting potential issues of conflict. These issues are discussed in the following section, examining alternative management scenarios from which SMP2 policy is then derived.

STAKEHOLDER OBJECTIVE	NAI			WPM		
	Fails	Neutral	Acceptable	Fails	Neutral	Acceptable
Reduce risk to life						
Protect properties from flood and erosion loss						
Minimise the need for increasing effort and management of coastal defences						
Avoid reliance on defence particularly where there is a risk of catastrophic failure						
Highlight areas long term sustainability issue and where there may need to be relocation						
Maintain connectivity along the estuaries to main centres in land						
Maintain connectivity between local communities along the coast						
Maintain Porthmadog and Criccieth as a critical centre						
Maintain recreational use of beaches						
Maintain access to the coast including car parking and facilities						
Maintain access for boat use and associated water sport activity						
Maintain the opportunity for sustainable adaptation of the main Golf Course						
Maintain the opportunity for sustainable adaptation of the main Holiday centres.						
Maintain the economic viability of Porthmadog/Pwllheli economic hub						
Maintain character and integrity of coastal communities						
Maintain the ability for adaptation and opportunity for economic growth of small communities						
Maintain agricultural value of rural community						
Identify risk and reduce risk of loss of heritage features where possible						
Maintain historic landscape						
Prevent disturbance or deterioration to historic sites and their setting						
Maintain or enhance the condition or integrity of the international (SAC, SPA) designated sites and interest features within the context of a dynamic coastal system.						
Maintain or enhance the condition or integrity of the national (SSSI) designated sites and interest						

STAKEHOLDER OBJECTIVE	NAI			WPM		
	Fails	Neutral	Acceptable	Fails	Neutral	Acceptable
features within the context of a dynamic coastal system.						
Maintain and enhance educational and scientific understanding of geology and geomorphology						
Avoid damage to and enhance the natural landscape.						
Maintain the human landscape and character of communities						
Maintain the critical road network						
Maintain the critical rail network.						

5 Discussion and Detailed Policy Development

The No Active Intervention scenario throws up some major issues with respect to maintaining the social and economic structure of the area. These issues arise in quite specific areas within the zone, while in other areas and more generally this scenario is sensible and allows natural development of the important shoreline features. The With Present Management scenario really focuses in on those areas under scenario 1 where there are the major management issues. However, the general approach in many of these areas is the quite blunt approach of Hold the Line. This was developed over the 50 year period of SMP 1 and with lower anticipated sea level rise scenarios and may have been acceptable in terms of the ability to mange defence over that period time. However, when taken from the longer time period of the SMP 2 and when taken from a perspective of setting out a sustainable plan that can be developed beyond the 100 years, this quite rigid approach to defence starts to become questionable.

These issues are discussed over the same areas as used in scenario 2.

Mochras and the Artro Estuary.
There are no overriding issues in terms of allowing the natural erosion of the Mochras cliff. The plan approach here would be for continued No Active Intervention. The most appropriate adjustment to this management approach would be to relocate the few hard features such as the car park and the road to the Artro southern headland. This maintains the natural function of the shoreline and delivers the important environmental objectives for the area.

In contrast there is significant value and strategic importance in maintaining the defence to the Llandanwg headland. This is not seen as having a significant impact on the behaviour of the Harlech dunes to the north, but does, in addition to maintaining important transport routes; provide a basic structure within which a more adaptive approach can be taken to management of the Artro Estuary frontage.

It is really within the central section of the coast that the more difficult issues arise. There are difficult problems in managing the northern dune frontage to the estuary. These arise from pressure both from within the estuary and along the shoreline. The difficulty is that this dune system is being squeezed and that there is insufficient width to allow it to be sustained into the long term. Any attempt to anchor the front face will start a process through which that defence will either be abandoned in the future with sudden failure ensuing or will lead to the hardening of the frontage and the loss of the dunes.

Within the estuary there are similar longer term issues. Maintaining the strategic rail and road routes through the area are considered essential and there is little opportunity to move these routes. Equally defence of these routes is going to become significantly more difficult. More locally but potentially of strategic importance is the access road to the airfield. If the airfield were to be developed in the future this would need to address the long term issue of flood risk to the access road.

Many of these problems, both within the estuary and at the shoreline, appear to derive from the change in shape of the estuary when the northern entranced opened but the inner part of the estuary was then still constrained by the defended position of channels and by the development of infrastructure based on historic locations.

Taken individually, management of any of the areas, with the exception of the two major assets of the road and railway line give very little economic justification for management.

Taken more broadly, the estuary offers potential benefits for development (of the airfield if sustainable access could be ensured), for developing the recreational water use and for opening opportunity for potentially significant environmental enhancement.

In principle, a more naturally functioning estuary might be achieved by encouraging a change of the main channel through the valley behind Morfa Mawr. This would require relocation of property and construction of a new bridge to the access road. The benefits of this could be creating more natural habitat but also removing a lot of the pressure on the defences to the road and railway line to the northeast. The potential is also there then for creating width to the dune spit and potentially re-connecting the dunes to the north within the estuary to the open shore dune system.

The opportunity is there to take a far broader scale approach to management of the area. Developing this in detail goes well beyond the scope of the SMP. However, it is the role of the SMP to identify this potential and through highlighting this to ensure short term actions would not close off this opportunity.

The preferred plan is for re-examining the whole behaviour of the estuary and developing a sustainable development plan. This would need to involve the highway authority, the railway and the National Park planners, as well as local interest groups such as the Llandanwg Dune Protection Group, the owners of the Mochras Headland and the National Trust.

To allow a more adaptive approach to be taken, while along the southern spit, maintaining the rock defence would not run counter to such an approach, along the northern spit any attempt to fix the dunes in a linear position should be avoided. Subject to detailed study and approval a more adjustable approach could be taken to assisting maintaining the dunes in the short term. The preferred policy approach for the area would therefore be for managed realignment at the short term sufficient to allow establishing a long term management plan for the whole area. Within the estuary, there would be a Hold the Line policy in the short term again aimed at providing the opportunity for developing a long term plan. These two policy units would then in effect merge as one with the medium to long term intent for managed realignment.

If this concept was not taken forward and it was decided that a long term management plan would not be developed, then management of individual frontages would be based on their local economic justification. Apart from the defence of the railway and the main road the policy for all other areas would be No Active Intervention.

Harlech Dunes and Harlech Valley.
There is a strong economic case for continued management of the main Harlech Valley. Furthermore it seems sensible that management should be maintained at the northern end, avoiding the need for more extensive defences along the sides of the valley to the road and to properties of Lower Harlech. This would also sustain the use of the railway through the valley.

The main Morfa Harlech dune frontage would be allowed to develop naturally meeting both the important nature conservation objectives while also providing a sustainable flood defence to the valley behind. In managing this frontage in this way, any works that might require future hard management should be avoided. As such there would be concern as to further drainage through the dunes which might either constrain dune behaviour or might rely upon a future need to modify the natural behaviour system. This throws up the issue of water level management within the valley, not just in relation to

the Golf Course, where there are already some issues but in terms of ensuring adequate surface water drainage to the whole area. This requires some form of water level management plan to be established that goes beyond the normal scope of the nature conservation interest to critically examine the potential flood risk in the future and future development of an integrated spatial plan fro the area. In addition to the drainage issue for the Golf Course which would need to be considered, in the long term, probably beyond the 100 years of SMP2 there are potential issues with providing adequate flood defence to Lower Harlech. This would be very dependent of the actual rate of sea level rise. This needs to be incorporated, from a planning and building control perspective in management of the area. There is also the potential risk of flooding across the north of the Morfa Harlech area. There is also the issue that in defending the main valley, this could result in coastal squeeze of saltmarsh in the future.

In this latter case, consideration could be given to opportunities for allowing some saline intrusion into the valley, taking the advantage of large areas for habitat enhancement within the area of the valley. This could allow some degree of warping up of the valley floor in a controlled manner that would create a better balanced situation in the future.

The basic policies would be for No Active Intervention along Morfa Harlech and the Ynys Llanfihangel-y-traethau headland and for Hold the Line to the defence at Ynys across the entrance to the valley. This should be subject to more detailed examination of water level management and development of a long term spatial approach to planning within the area.

Talsarnau.
Hold the Line is seen as being sustainable to this frontage over the first epoch. The two key interests and justifications for this would be the railway and the lower part of Talsarnau. By epoch 3 it seems unlikely that defence of the whole area would be sustainable with sea level rise. There would need to be significant improvements to defences and it is questionable that this could be justified considering the further technical difficulties of managing the present alignment of defence. Furthermore, there is likely to be continuing squeeze of the estuary habitat and that any major improvement in defence would be counter to the objectives for the nature conservation. Defence of Talsarnau and maintaining the road and railway would still be important drivers for continued management.

This area does lend itself to further consideration of managed realignment. The land has these very obvious ridges, which would strongly suggest high rock ridges underlying the area, with natural deeper valleys between. The railway runs some distance behind the defences and tends to follow a line taking better advantage of the higher ground. The village of Talsarnau is also constructed over this higher ground, as is the road running along the toe of the old coastal slope.

Subject to more detailed investigation, the policy for this area would be for initially Hold the Line, but for Managed Realignment in epochs two and three. The aim of this would be to establish a set back line of defence either at the railway line of along the ridge, just north of Talsarnau, running through to Draenogan Mawr.

Upper Dwyryd
There would be no economic justification for defence in this area and maintaining defence would incur damage to the internationally designated area. The policy for this area would initially be for Managed Realignment with the future policy for No Active Intervention. This would not preclude local defence to the main roads

Porthmadog.
There is major benefit in maintaining defence to the town and as such maintaining the cob. Management of defence upstream of the Cob would need to be examined further as indicted by the CFMP. As sea level rises there would also be a need to look to raising defence in the area of the Wharf so as to maintaining defence to the town.

At Borth-y-Gest the policy all three epochs would be for Hold the Line as this defence is seen as essential for maintaining access to the large development within the village. However, further consideration should be given to adapting the road into the village from the east potentially even raising this as a bridged section. This could give more scope for more sustainable management of the sea front and would address the longer term safety risk of access to the community.

Morfa Bychan.
Management of and maintaining the dunes is essential in this area, allowing them to develop as a properly functioning system. This is important from a nature conservation perspective but also in providing a robust natural defence against flooding. There is some residual flood risk at present to areas of the village, but principally to areas of the Holiday Parks (Greenacres Holiday Park, Garreg Goch Caravan Park and Cardigan View Holiday Park). This risk becomes substantially greater with sea level rise over the next 100 years. While there may be scope for reducing the flood risk through landscaped defences over the area of these Holiday Parks, there is risk of more widespread flooding in the future from several different directions, both along the watercourses and from the rear of the village.

The policy over this area is for managed realignment, supporting the natural protection provided by the dune system. Any attempt to reinforce the front face of the dunes is likely to reduce the ability of the dunes to respond to storm events. This would result in further need for artificial defences. Behind this natural front line of defence, there may be the need for more local flood defence. This needs to be considered in detail in the longer term, building in greater resilience to properties and more adaptive use of the Holiday Park area. Such an approach is encompassed by the overall policy for Managed Realignement.

Criccieth East and Eastern Shingle Banks.
Hold the Line through management of the shingle ridges in not seen as being sustainable possibly much beyond epoch one. The typical alternative approach in holding the line would for hard defence along the railway frontage. This would be setting in train an approach, which with sea level rise, would be unsustainable in the future. Hardening of the defence in the centre would be potentially manageable, in effect replicating the natural emergence of the rock headland in this area. Critical to sustaining the railway line would be establishing its level over the length. There is seen as being some potential opportunity to realign the railway further inland along the road through Pentrefelin, this in the long term could allow a more natural approach to be taken along the shoreline. Assessing the feasibility of this goes beyond the remit of the SMP.

Given that the railway line is to be retained over the frontage there is scope for developing the natural rock headland to better control the behaviour of the frontage and this starts to interact with the management of the Criccieth frontage to the west.

Along the Criccieth frontage, the problem is that to sustain the important defence over the whole bay, there would need to be significant reinforcing defences along the linear

frontage. In order that the amenity in this area is not lost a preferred approach would be to examine the potential of increasing the protection provided by the Harbour breakwater and the degree of control provided by the groyne to the eastern end of the bay. This could give opportunity for beach recharge to be retained.

In developing this consideration would need to be given as to how this could be aligned with the increasing control of the shingle banks to the east.

The policies through this area would be for holding the line to both frontages over epoch one. This would change to managed realignment of the railway frontage in epoch two and for the need for managed realignment along the harbour frontage during epoch three.

Criccieth West to Pen ychain
Along the west Criccieth frontage the policy would be for Hold the Line. This is seen as economically justified and sustainable given continuing the policy for No active intervention further west.

Along the Dwyfor frontage, the policy in the first epoch would be for Managed Realignment, recognising that there are issues with existing defences in the area. However, this would be with a longer term intent to allow the frontage to develop more naturally in the future. This may put the railway line at risk from increased flooding, with the potential that major works might be required in epoch three to sustain this route. This clearly has implications with respect to defence of the railway at Afon Wen. The current practice of linear defence is not seen as being sustainable in the long term, even if it were justified against the value of the railway.

There might be scope for some realignment of coast through use of breakwaters to help retain sediment. Even so, this might under a more extreme sea level rise scenario only delay the need to reconsider the route of the railway. If this were reconsidered in conjunction with addressing the future risk at the Afon Dwyfor then there may be scope for redeveloping the railway along the back of the whole coastal area from Criccieth through to the Afon Wen. The potential for relocating the railway is recognised to be outside the scope of the SMP.

If such relocation is not possible then the alternative approach of considering potential realignment of the shoreline, with potential for beach recharge, would be considered more sustainable than the current linear approach to defences. In particular, this would provide opportunity to resolve issues in terms of maintaining the geological exposure of the clay cliffs and would tend to mitigate to some degree the impact on the SAC.

The policy for the Eastern Pen ychain frontage would be for No Active Intervention. This might not exclude local private management subject to normal approvals.

6 Management Summary.

The zone may be divided into five Management Areas and the policy units within each area is summarised below.

MA 26 ARTRO ESTUARY: From Mochras to Llandanwg Headland

Policy Unit		Policy Plan			
		2025	2055	2105	Comment
12.1	Mochras	NAI	NAI	NAI	Relocation of assets during epoch 2
12.2	Artro Southern Spit	HTL	MR	MR	Maintain control of the spit while considering overall management plan
12.3	Artro Estuary south	HTL	MR	MR	Local management of defences subject to developing a management plan. The default policy would be for NAI.
12.4	Artro Estuary East	HTL	HTL	HTL	Maintain defence to the road and railway.
12.5	Llandanwg Dunes	MR	MR	MR	Local management of defences subject to developing a management plan. The default policy would be for NAI.
12.6	Llandanwg Headland	HTL	HTL	HTL	
Key: HTL - Hold the Line, A - Advance the Line, NAI – No Active Intervention MR – Managed Realignment					

MA 27 HARLECH AND THE DWYRYD ESTUARY: From Llandanwg Headland to the Cob

Policy Unit		Policy Plan			
		2025	2055	2105	Comment
12.7	Morfa Harlech	NAI	NAI	NAI	This would preclude any actions to intervene with natural processes.
12.8	Harlech Valley	HTL	HTL	HLT	Develop a water level and spatial management plan, considering drainage issues, potential for habitat recreation and long term sustainable management of flood risk at Lower Harlech
12.9	Talsarnau	HTL	MR	MR	Realignment either to railway line in the north or to the old cliff line.
12.10	Briwet and Dwyryd Gorge	NAI	NAI	NAI	Maintain toll road and railway line
12.11	Upper Dwyryd Estuary	MR	NAI	NAI	Local management of defences to maintain main roads
12.12	Penrhyndeudraeth Headland	NAI	NAI	NAI	This might not preclude local private management of defences subject to normal approvals.
Key: HTL - Hold the Line, A - Advance the Line, NAI – No Active Intervention MR – Managed Realignment					

MA 28 HARLECH AND THE DWYRYD ESTUARY: From the Cob to Graig Ddu

Policy Unit		Policy Plan			
		2025	2055	2105	Comment
12.13	The Cob and Porthmadog	HTL	HTL	HTL	Further investigation of improving defences to town as identified by the CFMP.
12.14	Borth-y-Gest	HTL	HTL	HLT	Consideration of adapting road to ensure long term safe access to community
12.15	Samson Bay	NAI	NAI	NAI	
12.16	Morfa Bychan	MR	MR	MR	Sustain natural dune defence with management of access. Develop a long term management plan for adaptation within Holiday Park area and potential future requirement of management of flood risk to village,.
Key: HTL - Hold the Line, A - Advance the Line, NAI – No Active Intervention MR – Managed Realignment					

MA 29 CRICCIETH EAST AND EASTERN SHINGLE BANKS: From Graig Ddu to Criccieth Castle

Policy Unit		Policy Plan			
		2025	2055	2105	Comment
12.17	Criccieth Shingle Banks	HTL	MR	MR	Consideration of potential to realign the railway
12.18	Criccieth Harbour	HTL	HTL	MR	Look to realign the shoreline to the frontage through development of the Harbour pier and eastern end of The Esplanade to retain the beach.
12.19	Castle Headland	NAI	NAI	NAI	
Key: HTL - Hold the Line, A - Advance the Line, NAI – No Active Intervention MR – Managed Realignment					

MA 30 CRICCIETH WEST: From Criccieth Castle to Pen ychain

Policy Unit		Policy Plan			
		2025	2055	2105	Comment
12.20	Criccieth West	HTL	HTL	HTL	.
12.21	Y Dryll	NAI	NAI	NAI	
12.22	Dwyfor	MR	NAI	NAI	Consider impact on railway
12.23	Glanllynnau Cliffs	NAI	NAI	NAI	Maintain geological exposure
12.24	Afon Wen	HTL	MR	MR	Concerns over long term sustainability. Consider possible realignment in land of the railway.
12.25	Pen ychain east	NAI	NAI	NAI	This might not preclude local private management of defences subject to normal approvals.
Key: HTL - Hold the Line, A - Advance the Line, NAI – No Active Intervention MR – Managed Realignment					

PDZ12
Management Area Statements

MA 26 Artro Estuary
Mochras to Llandanwg Headland

MA 27 Harlech and the Dwyryd Estuary
Llandanwg Headland to The Cob

MA 28 Porthmadog
The Cob to Graig Ddu

MA 29 Criccieth East and Eastern Shingle Banks
Graig Ddu to Criccieth Castle

MA 30 Criccieth West
Criccieth Castle to Pen ychain

Location reference:	**Artro Estuary**
Management Area reference:	**M.A. 26**
Policy Development Zone:	PDZ12

* Note: Predicted shoreline mapping is based on a combination of monitoring data, analysis of historical maps and geomorphological assessment with allowance for sea level rise. Due to inherent uncertainties in predicting future change, these predictions are necessarily indicative. For use beyond the purpose of the shoreline management plan, reference should be made to the baseline data.

The following descriptions are provided to assist interpretation of the map shown overleaf.

100 year shoreline position:
The following maps aim to summarise the anticipated position of the shoreline in 100 years under the two scenarios of "With Present Management" and under the "Draft Preferred Policy" being put forward through the Shoreline Management Plan.

- In some areas the preferred policy does not change from that under the existing management approach. In some areas where there are hard defences this can be accurately identified. In other areas there is greater uncertainty. Even so, where the shoreline is likely to be quite clearly defined by a change such as the crest of a cliff the estimated position is shown as a single line.

- Where there is a difference between With Present Management and the Draft Preferred Policy this distinction is made in showing two different lines:

  With Present Management.
  Draft Preferred Policy.

Flood Risk Zones

General Flood Risk Zones. The explanation of these zones is provided on the Environment Agency's web site www.environment-agency.gov.uk. The maps within this Draft SMP document show where SMP policy might influence the management of flood risk.

Indicate areas where the intent of the SMP draft policy is to continue to manage this risk.

Indicate where over the 100 years the policy would allow increased risk of flooding.

The maps should be read in conjunction with the text within the Draft SMP document.


Shoreline Management Plan Sub Cell 10
Baseline Location Map
Management Area 26
Management Area
Policy Unit
Policy Development Zone
Scheduled Monument
N
Holyhead
Bangor
Caernarfon
Dolgellau
Aberystwyth
Llanguric
Fishguard
Carmarthen
Swansea
55
56
57
59
MA26
PU12.1
PU12.2
PU12.3
PU12.4
PU12.5
PU12.6
PU11.20
Mochras
(Shell Is)
Bar Newydd
Llandanwg
Llanfair
Harlech
Maesyraelfor
Groes
Hotel
Airfield
Morfa Dyffryn Dunes
A 496
Faeldre
Ynys-Gwyn
Llanenddwyn
Coed Ystumgwern
0
0.5
1 Kilometres
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Key
100 Year Shoreline Position:
Preferred Policy would be the same as With Present Management
With Present Management where this differs from the Preferred Policy
Preferred Policy where this differs from the With Present Management
Ramsar
SAC
SPA
SSSI
NNR
Exisitng Indicative EA Flood Zone 3
EA Flood Risk Zone 2 where under the SMP policy there would be increased probability of flooding
ROYAL HASKONING
I:\9T9001\Technical_Data\GIS\Projects\SMP_Report_Figures\Management Areas

SUMMARY OF PREFERRED PLAN RECOMMENDATIONS AND JUSTIFICATION

INTENT OF THE PLAN:

To the north of the area is the headland at Llandanwg. The intent of the plan along this frontage is to continue to defend the railway line and main road and in doing so also protect property at risk from erosion. This together with the slowly eroding headland of Mochras provides a degree of control to the shoreline between, including the existing entrance to the Artro Estuary.

The estuary entrance used to be to the south of Mochras and the estuary, constrained by man made defences, has been attempting adjust to its new entrance since this was formed. The intent of the plan is to allow the Mochras headland to erode but to adjust management of the entrance and within the estuary in such a manner as to allow the estuary to adopt a more naturally functioning shape. This would establish a more sustainable position from which to develop future management.
The estuary has areas of defended agricultural land with defended properties. There are also a wide variety of issues and interests associated with the estuary and the use of the estuary. Access to Mochras and the airfield is through the natural flood plain of the estuary, with the road to Mochras being tidal.

The aim of the plan is to encourage realignment of defences. However, this needs to be developed alongside a fully integrated plan for management and use of the estuary. Key elements of the plan would be to maintain the main road and railway line and to continue to manage the flood risk to the village of Llanbedr. Future development of the airfield would need to take account of areas of flood risk, the potential need to realign the access and the potential impact any development might have on the Dyffryn Dune system. The Plan does not define specifically where managed realignment might be required but it might be anticipated that defence might be abandoned around Morfa Mawr.

Realignment within the estuary has the potential to improve the dunes just south of Llandanwg and to allow better width and scope to mange the shoreline. The intent of the plan is to support local management at the shoreline, subject to normal approvals but on the basis that this would not impose hard defence of the frontage.

The SMP recognises the complex variety of issues associated with the estuary and the immediate shoreline and through this intent of managed realignment based on an integrated plan, developed through community involvement, aims to establish a more sustainable way of sustaining these variety of interests.

KEY ISSUES/RISK AND UNCERTAINTY:

There are uncertainties in terms of timing of impacts although the current pressure on management of the foreshore and throughout the northern part of the estuary means that planning for change is required within epoch 1. It will be important to relate development of the plan to national monitoring of sea level rise and more general climate change.
Funding for defence and for change will be an issues and it is unlikely that FCERM could be relied upon as a major source of funding. Alternative funding sources may need to come from within the communities involved, together with involvement from organisations whose assets are at risk. The approach to future development of the airfield would need to recognise and be involved with potential funding arrangements. In the absence of an agreed plan the policy over much of the estuary and shoreline would by default be NAI.

ACTIONS:		
ACTION	PARTNERS	
Shoreline monitoring	**GC**	**Local action group**
Adaption planning and estuary management plan	**GC** **Communities** **Network Rail** **SNPA** **CCW**	 **EA** **Highways** **NT**
Assess in detail potential impact on historic environment	**CADW**	
Examine potential opportunities fro habitat creation	**CCW**	**GC**

DELIVERY OF THE PLAN

SUMMARY OF SPECIFIC POLICIES

Policy Unit		**Policy Plan**			
		2025	**2055**	**2105**	**Comment**
12.1	Mochras	NAI	NAI	NAI	Relocation of assets during epoch 2
12.2	Artro Southern Spit	HTL	MR	MR	Maintain control of the spit while considering overall management plan
12.3	Artro Estuary south	HTL	MR	MR	Local management of defences subject to developing a management plan. The default policy would be for NAI.
12.4	Artro Estuary East	HTL	HTL	HTL	Maintain defence to the road and railway.
12.5	Llandanwg Dunes	MR	MR	MR	Local management of defences subject to developing a management plan. The default policy would be for NAI.
12.6	Llandanwg Headland	HTL	HTL	HTL	
Key: HTL - Hold the Line, A - Advance the Line, NAI – No Active Intervention MR – Managed Realignment					

PREFERRED POLICY TO IMPLEMENT PLAN:	
From present day	Maintain existing defences to Llandanwg Headland. Local management of the shoreline and maintain entrance. Develop integrated management plan.
Medium term	Maintain existing defences to Llandanwg Headland. Implement integrated management plan
Long term	Maintain existing defences to Llandanwg Headland. Review and implement integrated management plan

IMPLICATIONS OF THE PLAN

CHANGES FROM PRESENT MANAGEMENT

Recognising the important and varied interests of the area the SMP recommends development of an integrated plan. Within the estuary and at the shoreline the approach changes from NAI to managed realignment.

ECONOMIC SUMMARY

Economics (£k PV)	by 2025	by 2055	by 2105	Total £k PV
NAI Damages	130.7	314.6	547.2	992.5
Preferred Plan Damages	130.7	264.6	258.9	654.2
Benefits	0.0	50.0	288.3	338.3
Costs	141.8	1,432.0	0.0	1,573.8

FLOOD AND EROSION RISK MANAGMENT

POTENTIAL LOSS

Potential losses due to erosion and increased flood risk would be subject to the integrated management plan. It would however be anticipated that there would be loss of property and existing use in the area of Morfa Mawr and in terms of development to the airfield.

BENEFITS OF THE PLAN

The plan supports an intent to develop a sustainable plan for long term management of the area. The plan would continue to protect some 7 properties at risk from erosion and would aim at reducing flood risk to over 30 properties in the area.

SUMMARY OF STRATEGIC ENVIRONMENTAL ASSESSMENT (INCLUDING HRA)

PDZ 12				
SEA Objective	**Impact of Preferred Policy for each Epoch**			
	1	**2**	**3**	**Mitigation**
Policy Units 12.1 to 12.25				
To support natural processes, maintain and enhance the integrity of internationally designated nature conservation sites. Maintain / achieve favourable condition of their interest features (habitats and species).				Habitat creation
To avoid adverse impacts on, conserve and where practical enhance the designated interest of nationally designated nature conservation sites. Maintain/achieve favourable condition.				Habitat creation
To avoid adverse impacts on, conserve and where practical enhance national and local BAP habitats.				Habitat creation
To support natural processes and maintain geological exposures throughout nationally designated geological sites.				
To conserve and enhance nationally designated landscapes in relation to risks from coastal flooding and erosion and avoid conflict with AONB and National Park Management Plan Objectives.				Appropriate design
To minimise coastal flood and erosion risk to scheduled and other internationally and nationally important cultural heritage assets, sites and their setting.				Excavation and recording
To minimise the impact of policies on marine operations and activities.				Monitoring and appropriate design
To minimise coastal flood and erosion risk to critical infrastructure and maintain critical services.				Relocation or realignment
To minimise coastal flood and erosion risk to agricultural land and horticultural activities.				
To minimise coastal flood and erosion risk to people and residential property.				
To minimise coastal flood and erosion risk to key community, recreational and amenity facilities.				
To minimise coastal flood and erosion risk to industrial, commercial, economic and tourism assets and activities.				Relocation

Examination of potential habitat creation within the Artro Estuary.

This table provides a summary of the SEA (appendix E) and reference should be made to the Appendix for full details of the assessment.

These next two sections provide a headline summary of the findings of the HRA (Appendix G) and the WFA (Appendix H). Reference should be made as appropriate to these Appendices for full details.

HRA SUMMARY

Anticipated Habitat Loss in PDZ 12 as a result of SMP Policy

Designated Site	PU	Habitat Type	Extent of Loss of Habitat (ha)			
			Epoch 1	Epoch 2	Epoch 3	Total
Llŷn Peninsula and the Sarnau SAC	12.2	Intertidal sandflat	0.00			0.00
	12.3	Intertidal sandflat	0.00			0.00
	12.4	Intertidal sandflat	0.00	4.38	2.93	7.31
	12.6	Intertidal sandflat	0.00	2.11	1.83	3.94

Pen Llŷn a`r Sarnau/ **Llŷn Peninsula** *and the Sarnau SAC:* It is concluded that there would be an **adverse effect on the integrity** of the intertidal habitat (sandflat and saltmarsh) within the boundary of the SAC as a result of the SMP2 policies. There will however, be **no adverse effect on the integrity** of the other SAC features.

Morfa Harlech a Morfa Dyffryn SAC: **no adverse effect on the integrity of the SAC**.

Coedydd Derw a Safleoedd Ystlumod Meirion/ Meirionnydd Oakwoods and Bat Sites SAC: **no adverse effect on the integrity of the SAC**.

Preventative/mitigation measures: Potentially move defences landward where possible were feasible to allow mudflats to roll back in time with sea level rise.
Within the Morfa Harlech a Morfa Dyffryn SAC suggested mitigation measures may be to explore integrated management of the dunes as a whole to allow the body of the sand to migrate landward to maintain the dune system and their relevant position to the tidal frame.

Risks/Assumptions: The habitat loss is considered precautionary, and where any works are to be undertaken detailed study would provide an accurate identification of whether habitat would be lost and the extent. Potentially, given the worst case assumptions, further detail of the likely actions and site specific study may conclude no habitat loss, given the worst case scenario used in this assessment. The areas of potential habitat loss are relatively large, and this is exacerbated by the fact that such low lying areas would show a large scale change, but this does not take into account accretion of sediments within the estuary or how inundation of areas north of the Cob would influence the development of intertidal sandflat and saltmarsh. Consequently, the assumptions used to determine loss are expected to have resulted in much greater extents of habitat loss than would occur.

SUMMARY CONCLUSION FROM THE WATER FRAMEWORK ASSESSMENT

Water body (and relevant PDZ)	**Environmental Objectives met?**				**WFD Summary Statement required?**	**Achievement of Any South East RBMP Mitigation Measures?**	**Details on how the specific South East RBMP Mitigation Measures have been attained** (dark green = achieved; light green = partly achieved & red = not achieved)
	WFD 1	**WFD2**	**WFD3**	**WFD4**			
Cardigan Bay North (Coastal) (PDZs 9, 10, 11, part 12, part 13 and 14.) (MAN 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, part 26, 33, 34, 35, 36 and 37)	N/A	**x** (PDZ 10, 11)	**x** (PDZ 10, 11)	✓	**Yes** – Environmental Objectives WFD 2 and 3 may not be met because of the SMPs policy in PDZ 10 (MAN 20), PDZ 11 (MAN 21).	There were no relevant measures to the SMP2 for this water body, though there are for the affected FWBs.	Mitigation measures for the FWB (GB110064048310), of which none have been implemented within the SMP2: • Increase in-channel morphological diversity; • Structures or other mechanisms in place and managed to enable fish to access waters upstream and downstream of the impounding works; • Operational and structural changes to locks, sluices, weirs, beach control, etc; • Selective Vegetation Control Regime; • Appropriate Vegetation Control Technique; • Appropriate timing (Vegetation control); • Appropriate Techniques (Invasive Species); and • Retain marginal aquatic and riparian habitats (channel alteration).
Atro (Transitional) (PDZ part 12) (MAN part 26)	N/A	✓	✓	✓	**No** - not necessary as delivery of the WFD Environmental Objectives will not be prevented by the SMP policies and in some cases will ensure they	There were no relevant measures to the SMP2 for this water body.	N/A

Water body (and relevant PDZ)	**Environmental Objectives met?**				**WFD Summary Statement required?**	**Achievement of Any South East RBMP Mitigation Measures?**	**Details on how the specific South East RBMP Mitigation Measures have been attained** (dark green = achieved; light green = partly achieved & red = not achieved)
	WFD 1	**WFD2**	**WFD3**	**WFD4**			
					are of benefit.		
Tremadog Bay (Coastal) (PDZ part 12, part 13) (MAN part 26, 27, 28, 29, 30, 31, 32 and part 33)	N/A	✓	✓	✓	**No** - not necessary as delivery of the WFD Environmental Objectives will not be prevented by the SMP policies and in some cases will ensure they are of benefit.	There were no relevant measures to the SMP2 for this water body.	N/A

Location reference:	**Harlech and the Dwyryd Estuary**
Management Area reference:	**M.A. 27**
Policy Development Zone:	PDZ12

* Note: Predicted shoreline mapping is based on a combination of monitoring data, analysis of historical maps and geomorphological assessment with allowance for sea level rise. Due to inherent uncertainties in predicting future change, these predictions are necessarily indicative. For use beyond the purpose of the shoreline management plan, reference should be made to the baseline data.

The following descriptions are provided to assist interpretation of the map shown overleaf.

100 year shoreline position:
The following maps aim to summarise the anticipated position of the shoreline in 100 years under the two scenarios of "With Present Management" and under the "Draft Preferred Policy" being put forward through the Shoreline Management Plan.

- In some areas the preferred policy does not change from that under the existing management approach. In some areas where there are hard defences this can be accurately identified. In other areas there is greater uncertainty. Even so, where the shoreline is likely to be quite clearly defined by a change such as the crest of a cliff the estimated position is shown as a single line.

- Where there is a difference between With Present Management and the Draft Preferred Policy this distinction is made in showing two different lines:

  With Present Management.
  Draft Preferred Policy.

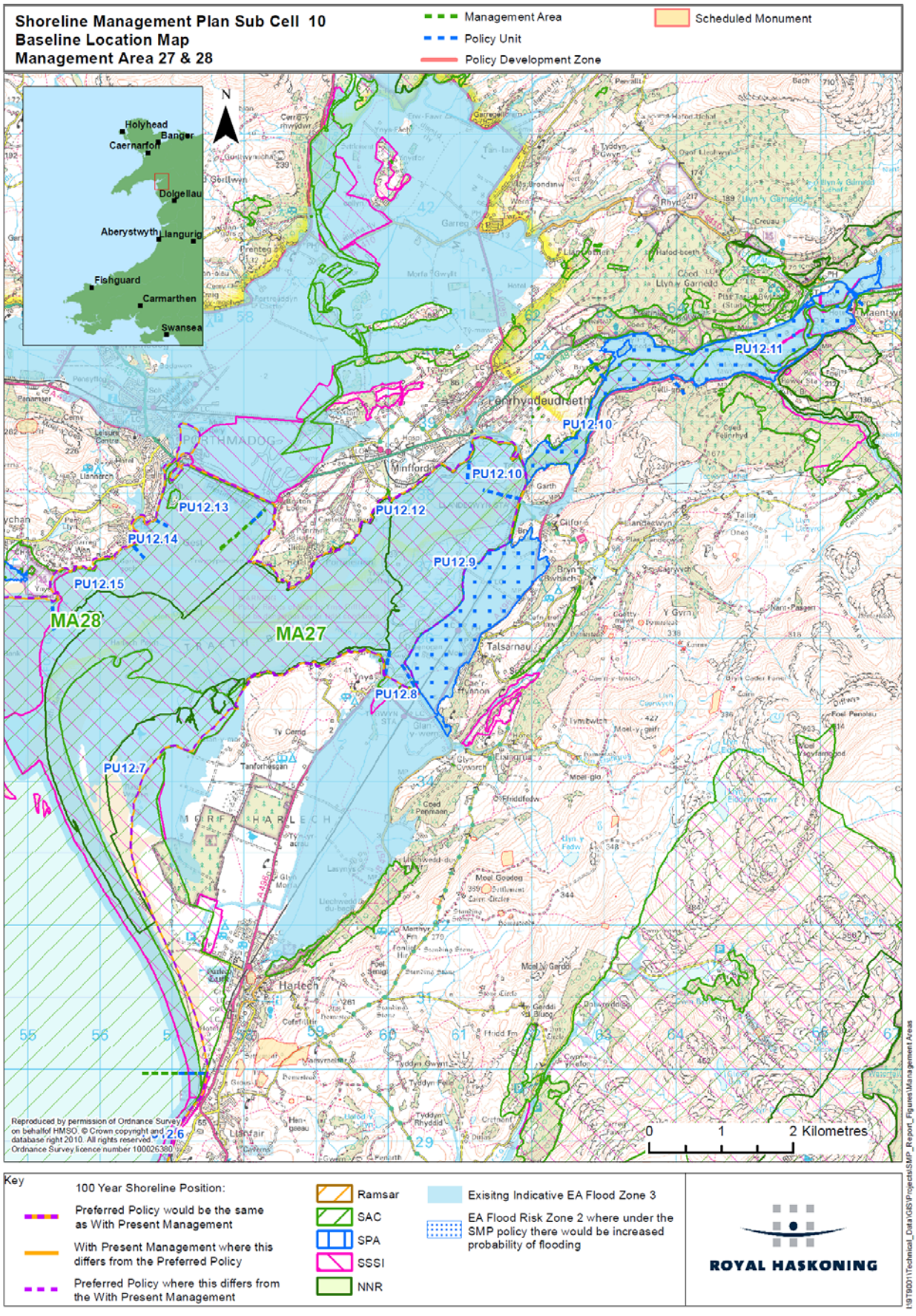
Flood Risk Zones

General Flood Risk Zones. The explanation of these zones is provided on the Environment Agency's web site www.environment-agency.gov.uk. The maps within this Draft SMP document show where SMP policy might influence the management of flood risk.

Indicate areas where the intent of the SMP draft policy is to continue to manage this risk.

Indicate where over the 100 years the policy would allow increased risk of flooding.

The maps should be read in conjunction with the text within the Draft SMP document.


Shoreline Management Plan Sub Cell 10
Baseline Location Map
Management Area 27 & 28
Management Area
Policy Unit
Policy Development Zone
Scheduled Monument
N
Holyhead
Bangor
Caernarfon
Dolgellau
Aberystwyth
Llanguric
Fishguard
Carmarthen
Swansea
PU12.11
PU12.10
PU12.10
PU12.12
PU12.13
PU12.14
PU12.15
PU12.9
PU12.8
PU12.7
MA28
MA27
Minffordd
Talsarnau
Harlech
Llanfair
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0
1
2 Kilometres
Key
100 Year Shoreline Position:
Preferred Policy would be the same as With Present Management
With Present Management where this differs from the Preferred Policy
Preferred Policy where this differs from the With Present Management
Ramsar
SAC
SPA
SSSI
NNR
Exisitng Indicative EA Flood Zone 3
EA Flood Risk Zone 2 where under the SMP policy there would be increased probability of flooding
ROYAL HASKONING
I:\9T9001\Technical_Data\GIS\Projects\SMP_Report_Figures\Management Areas

SUMMARY OF PREFERRED PLAN RECOMMENDATIONS AND JUSTIFICATION

INTENT OF THE PLAN:

The intent of the plan is to maintain the natural function of the Harlech dune system and to allow adaption within the Dwyryd Estuary to support nature conservation values. Alongside this the intent would be to continue to defend the Harlech Valley and to continue to provide defence to Talsarnau and maintain both the road and railway lines through the area.

Within the Harlech Valley there are already issues developing in terms of water level management, in particular associated with drainage to the golf course. This needs to be assessed through the development of long term integrated water level management plan for the area, looking to the longer term with respect to the potential need for future pumped drainage to the whole area. Drainage through the dune system runs the future risk that as the dunes develop and roll back such an approach might constrain the natural development of the dunes and reduce their capacity to act as a competent defence to the hinterland. There will be increased flood risk within the valley and development will need to be controlled appropriately.

Along the Talsarnau frontage, with sea level rise, there is likely to be a need to consider managed realignment to a more sustainable; position. This would provide width for development of saltmarsh further supporting defences measures. The intent of the plan is however to maintain defence to the core village area and the railway and road systems.

As sea level rises it would be unlikely that defence within the upper part of the Dwyryd Estuary could be sensibly sustained. The plan defines this as an area for initial realignment within the longer term intent for NAI. This would create width for development of natural saltmarsh. This would not preclude local defence to essential features such as the road.

KEY ISSUES/RISK AND UNCERTAINTY:

There are uncertainties in terms of timing of the proposed changes. There is also a need for a detailed planned response to change. It will be important to relate this to national monitoring of sea level rise and more general climate change.

ACTIONS:

ACTION	PARTNERS	
Shoreline monitoring	**GC**	
Adaptation planning ▪ Talsarnau. ▪ Upper Dwyryd	**EA** **Communities** **Network Rail** **SNPA**	 **Highways** **GC** **CCW**
Integrated water level plan	**GC** **SNPA** **Golf Course**	**EA** **Network Rail** **CCW**
Examine opportunities fro habitat creation	**EA**	**CCW**

DELIVERY OF THE PLAN

SUMMARY OF SPECIFIC POLICIES

Policy Unit		Policy Plan			
		2025	2055	2105	Comment
12.7	Morfa Harlech	NAI	NAI	NAI	This would preclude any actions to intervene with natural processes.
12.8	Harlech Valley	HTL	HTL	HTL	Develop a water level and spatial management plan, considering drainage issues, potential for habitat recreation and long term sustainable management of flood risk at Lower Harlech
12.9	Talsarnau	HTL	MR	MR	Realignment either to railway line in the north or to the old cliff line.
12.10	Briwet and Dwyryd Gorge	NAI	NAI	NAI	Maintain toll road and railway line
12.11	Upper Dwyryd Estuary	MR	NAI	NAI	Local management of defences to maintain main roads
12.12	Penrhyndeudraeth Headland	NAI	NAI	NAI	This might not preclude local private management of defences subject to normal approvals.
Key: HTL - Hold the Line, A - Advance the Line, NAI – No Active Intervention MR – Managed Realignment					

PREFERRED POLICY TO IMPLEMENT PLAN:	
From present day	Maintain existing defences. Consider realignment in front of Talsarnau and within the upper Dwyryd.
Medium term	Maintain defence to the Harlech Valley and realign in front of Talsarnau and within the upper Dwyryd.
Long term	Maintain defences.

IMPLICATIONS OF THE PLAN

CHANGES FROM PRESENT MANAGEMENT

At

ECONOMIC SUMMARY

Economics (£k PV)	by 2025	by 2055	by 2105	Total £k PV
NAI Damages	2,524.4	2,938.9	11,515.2	16,978.5
Preferred Plan Damages	398.6	614.5	712.7	1,725.9
Benefits	2,125.8	2,324.4	10,802.5	15,252.6
Costs	0.0	626.5	508.9	1,135.4

FLOOD AND EROSION RISK MANAGMENT

POTENTIAL LOSS

There is likely to be loss of 1 property due to erosion. There would be potential loss of property due to flooding in areas in front of Talsarnau in the long term.

BENEFITS OF THE PLAN

The plan provides a longer term sustainable approach to defence, maintaining defence to the core community areas. The plan continues to reduce flood risk to some 450 properties.

SUMMARY OF STRATEGIC ENVIRONMENTAL ASSESSMENT (INCLUDING HRA)

PDZ 12				
SEA Objective	**Impact of Preferred Policy for each Epoch**			
	1	**2**	**3**	**Mitigation**
Policy Units 12.1 to 12.25				
To support natural processes, maintain and enhance the integrity of internationally designated nature conservation sites. Maintain / achieve favourable condition of their interest features (habitats and species).				Habitat creation
To avoid adverse impacts on, conserve and where practical enhance the designated interest of nationally designated nature conservation sites. Maintain/achieve favourable condition.				Habitat creation
To avoid adverse impacts on, conserve and where practical enhance national and local BAP habitats.				Habitat creation
To support natural processes and maintain geological exposures throughout nationally designated geological sites.				
To conserve and enhance nationally designated landscapes in relation to risks from coastal flooding and erosion and avoid conflict with AONB and National Park Management Plan Objectives.				Appropriate design
To minimise coastal flood and erosion risk to scheduled and other internationally and nationally important cultural heritage assets, sites and their setting.				Excavation and recording
To minimise the impact of policies on marine operations and activities.				Monitoring and appropriate design
To minimise coastal flood and erosion risk to critical infrastructure and maintain critical services.				Relocation or realignment
To minimise coastal flood and erosion risk to agricultural land and horticultural activities.				
To minimise coastal flood and erosion risk to people and residential property.				
To minimise coastal flood and erosion risk to key community, recreational and amenity facilities.				
To minimise coastal flood and erosion risk to industrial, commercial, economic and tourism assets and activities.				Relocation

Examine opportunities fro habitat creation.

This table provides a summary of the SEA (appendix E) and reference should be made to the Appendix for full details of the assessment.

These next two sections provide a headline summary of the findings of the HRA (Appendix G) and the WFA (Appendix H). Reference should be made as appropriate to these Appendices for full details.

HRA SUMMARY

Anticipated Habitat Loss in PDZ 12 as a result of SMP Policy

Designated Site	PU	Habitat Type	Extent of Loss of Habitat (ha)			
			Epoch 1	Epoch 2	Epoch 3	Total
Llŷn Peninsula and the Sarnau SAC	12.8	Intertidal sandflat of which	0.03	2.82	3.71	6.56
	12.8	Saltmarsh	0.03	2.54	3.34	5.90
	12.9	Intertidal sandflat of which	0.20			0.20
	12.9	Saltmarsh	0.18			0.18

Pen Llŷn a`r Sarnau/ ***Llŷn Peninsula*** *and the Sarnau SAC:* It is concluded that there would be an **adverse effect on the integrity** of the intertidal habitat (sandflat and saltmarsh) within the boundary of the SAC as a result of the SMP2 policies. There will however, be **no adverse effect on the integrity** of the other SAC features.

Morfa Harlech a Morfa Dyffryn SAC: **no adverse effect on the integrity of the SAC**.

Coedydd Derw a Safleoedd Ystlumod Meirion/ Meirionnydd Oakwoods and Bat Sites SAC: **no adverse effect on the integrity of the SAC**.

Preventative/mitigation measures: Potentially move defences landward where possible (in particular within PU 12.9) were feasible to allow mudflats to roll back in time with sea level rise.
Within the Morfa Harlech a Morfa Dyffryn SAC suggested mitigation measures may be to explore integrated management of the dunes as a whole to allow the body of the sand to migrate landward to maintain the dune system and their relevant position to the tidal frame.

Risks/Assumptions: The habitat loss is considered precautionary, and where any works are to be undertaken detailed study would provide an accurate identification of whether habitat would be lost and the extent. Potentially, given the worst case assumptions, further detail of the likely actions and site specific study may conclude no habitat loss, given the worst case scenario used in this assessment. The areas of potential habitat loss are relatively large, and this is exacerbated by the fact that such low lying areas would show a large scale change, but this does not take into account accretion of sediments within the estuary or how inundation of areas north of the Cob would influence the development of intertidal sandflats and saltmarsh. Consequently, the assumptions used to determine loss are expected to have resulted in much greater extents of habitat loss than would occur.

SUMMARY CONCLUSION FROM THE WATER FRAMEWORK ASSESSMENT

Water body (and relevant PDZ)	**Environmental Objectives met?**				**WFD Summary Statement required?**	**Achievement of Any South East RBMP Mitigation Measures?**	**Details on how the specific South East RBMP Mitigation Measures have been attained** (dark green = achieved; light green = partly achieved & red = not achieved)
	WFD 1	**WFD2**	**WFD3**	**WFD4**			
Tremadog Bay (Coastal) (PDZ part 12, part 13) (MAN part 26, 27, 28, 29, 30, 31, 32 and part 33)	N/A	✓	✓	✓	**No** - not necessary as delivery of the WFD Environmental Objectives will not be prevented by the SMP policies and in some cases will ensure they are of benefit.	There were no relevant measures to the SMP2 for this water body.	N/A

Location reference:	**Porthmadog**
Management Area reference:	**M.A. 28**
Policy Development Zone:	PDZ12

* Note: Predicted shoreline mapping is based on a combination of monitoring data, analysis of historical maps and geomorphological assessment with allowance for sea level rise. Due to inherent uncertainties in predicting future change, these predictions are necessarily indicative. For use beyond the purpose of the shoreline management plan, reference should be made to the baseline data.

The following descriptions are provided to assist interpretation of the map shown overleaf.

100 year shoreline position:
The following maps aim to summarise the anticipated position of the shoreline in 100 years under the two scenarios of "With Present Management" and under the "Draft Preferred Policy" being put forward through the Shoreline Management Plan.

- In some areas the preferred policy does not change from that under the existing management approach. In some areas where there are hard defences this can be accurately identified. In other areas there is greater uncertainty. Even so, where the shoreline is likely to be quite clearly defined by a change such as the crest of a cliff the estimated position is shown as a single line.

- Where there is a difference between With Present Management and the Draft Preferred Policy this distinction is made in showing two different lines:

  With Present Management.
  Draft Preferred Policy.

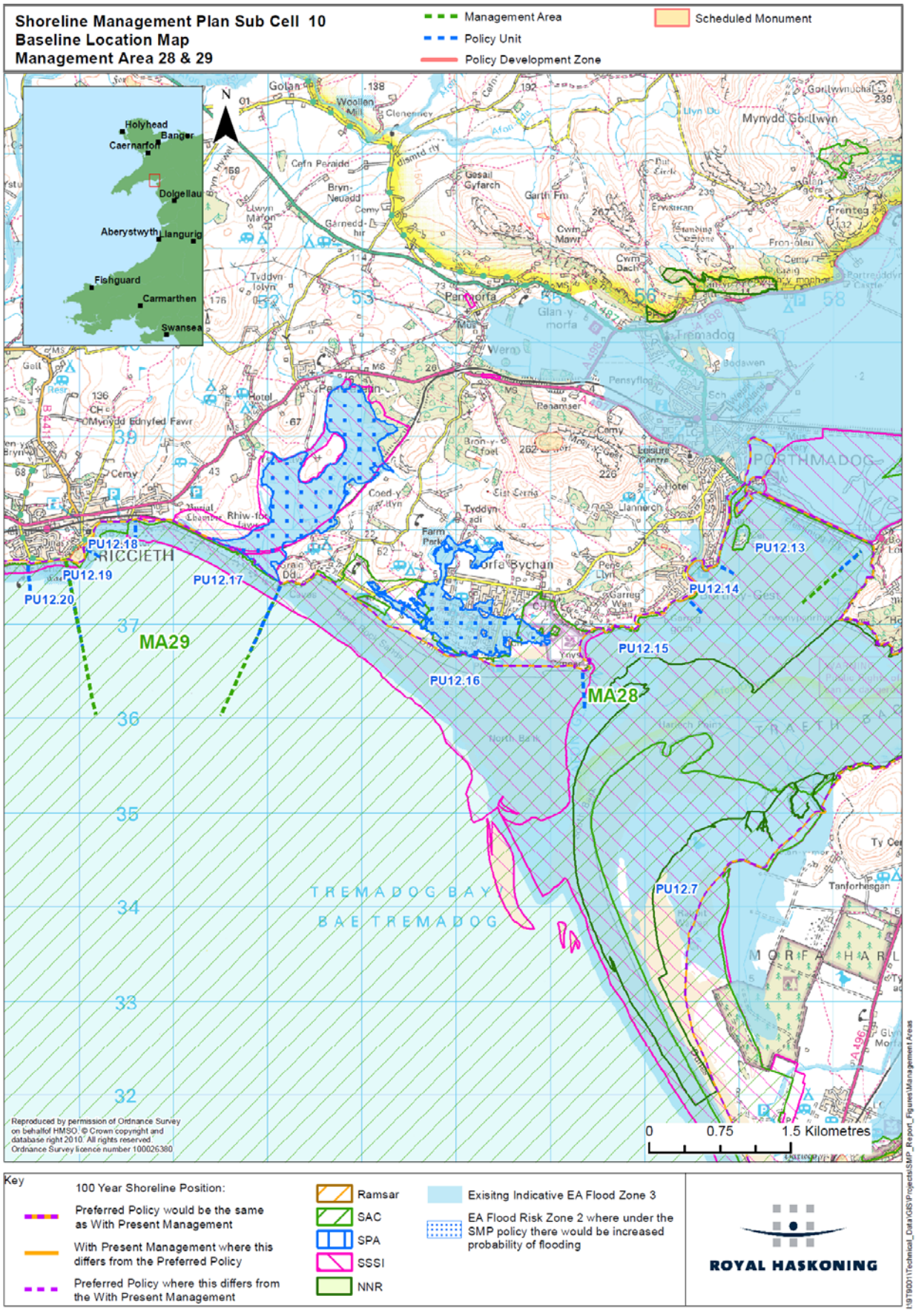
Flood Risk Zones

General Flood Risk Zones. The explanation of these zones is provided on the Environment Agency's web site www.environment-agency.gov.uk. The maps within this Draft SMP document show where SMP policy might influence the management of flood risk.

Indicate areas where the intent of the SMP draft policy is to continue to manage this risk.

Indicate where over the 100 years the policy would allow increased risk of flooding.

The maps should be read in conjunction with the text within the Draft SMP document.


Shoreline Management Plan Sub Cell 10
Baseline Location Map
Management Area 28 & 29
Management Area
Policy Unit
Policy Development Zone
Scheduled Monument
Holyhead
Bangor
Caernarfon
Dolgellau
Aberystwyth
Llanguric
Fishguard
Carmarthen
Swansea
PU12.18
PU12.19
PU12.20
PU12.17
PU12.13
PU12.14
PU12.15
PU12.16
PU12.7
MA29
MA28
TREMADOG BAY
BAE TREMADOG
0
0.75
1.5 Kilometres
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Key
100 Year Shoreline Position:
Preferred Policy would be the same as With Present Management
With Present Management where this differs from the Preferred Policy
Preferred Policy where this differs from the With Present Management
Ramsar
SAC
SPA
SSSI
NNR
Exisitng Indicative EA Flood Zone 3
EA Flood Risk Zone 2 where under the SMP policy there would be increased probability of flooding
ROYAL HASKONING

SUMMARY OF PREFERRED PLAN RECOMMENDATIONS AND JUSTIFICATION

INTENT OF THE PLAN:

The aim of the plan is to continue to provide defence to Porthmadog and at Borth y Gest and Morfa Bychan, but in the case of the latter two areas recognising the need for some adaptation

The intent of the plan would also be to maintain the Cob.

There is a very strong economic case for defence at Porthmadog, along side the significance of the town to the regional economy. Even so, there would be a significant residual risk of severe damage to the area if defence standards are exceeded. This needs to be reviewed and considered as part of the long term planning needs of the greater flood resilience to the community and function of the town.

At Borth y Gest there may be a need to adapt the road to ensure access is maintained to the village. The seafront is vulnerable to wave overtopping and this will need to be examined as sea level rises.

At Morfa Bychan, the integrity of the dune system is important both from a nature conservation value and as a front line of defence. It will be important to allow the dunes to function naturally and to maintain width for roll back. There is also flood risk along the streams. There may be a need to adapt the Holiday Parks to both sustain the dunes and to address future increase in flood risk. In the longer term there would be an increasing flood risk to the village. Adaptation of the village should be planned. There may also be scope for habitat creation within area with sea level rise.

KEY ISSUES/RISK AND UNCERTAINTY:

There are uncertainties in terms of timing of the proposed changes. There is also a need for a detailed planned response to change. It will be important to relate this to national monitoring of sea level rise and more general climate change.

ACTIONS:

ACTION	PARTNERS	
Shoreline monitoring	**GC**	
Adaption planning ▪ Borth y Gest ▪ Morfa Bychan	**GC** **Communities**	**Highways**
	SNPA	**NT**
	EA	**CCW**
Assess in detail potential impact on historic environment	**CADW**	
Examine opportunity for habitat creation	**EA**	**CCW**

DELIVERY OF THE PLAN

SUMMARY OF SPECIFIC POLICIES

Policy Unit		Policy Plan			
		2025	2055	2105	Comment
12.13	The Cob and Porthmadog	HTL	HTL	HTL	Further investigation of improving defences to town as identified by the CFMP.
12.14	Borth-y-Gest	HTL	HTL	HTL	Consideration of adapting road to ensure long term safe access to community
12.15	Samson Bay	NAI	NAI	NAI	
12.16	Morfa Bychan	MR	MR	MR	Sustain natural dune defence with management of access. Develop a long term management plan for adaptation within Holiday Park area and potential future requirement of management of flood risk to village,.
Key: HTL - Hold the Line, A - Advance the Line, NAI – No Active Intervention MR – Managed Realignment					

PREFERRED POLICY TO IMPLEMENT PLAN:	
From present day	Maintain existing defences. Maintain integrity of Morfa Bychan dunes through access management.
Medium term	Maintain existing defences. Maintain integrity of Morfa Bychan dunes through access management. Plan adaptation
Long term	Maintain existing defences. Maintain integrity of Morfa Bychan dunes through access management. Implement adaptation.

IMPLICATIONS OF THE PLAN

CHANGES FROM PRESENT MANAGEMENT

No substantial change.

ECONOMIC SUMMARY

Economics (£k PV)	by 2025	by 2055	by 2105	Total £k PV
NAI Damages	90,485.1	85,355.8	260,939.3	436,780.1
Preferred Plan Damages	4,534.2	4,735.2	5,143.4	14,412.8
Benefits	85,950.9	80,620.6	255,795.9	422,367.4
Costs	34.2	883.1	1,073.4	1,990.7

FLOOD AND EROSION RISK MANAGMENT

POTENTIAL LOSS

There may be long term loss of 2 properties and long term increased risk of flooding at Morfa Bychan.

BENEFITS OF THE PLAN

The plan provides a longer term sustainable approach to defence, maintaining defence to the core community areas. The plan would continue to improve flood defence to over 1500 properties and provide continued erosion protection to over 100 properties.

SUMMARY OF STRATEGIC ENVIRONMENTAL ASSESSMENT (INCLUDING HRA)

PDZ 12				
SEA Objective	**Impact of Preferred Policy for each Epoch**			
	1	**2**	**3**	**Mitigation**
Policy Units 12.1 to 12.25				
To support natural processes, maintain and enhance the integrity of internationally designated nature conservation sites. Maintain / achieve favourable condition of their interest features (habitats and species).				Habitat creation
To avoid adverse impacts on, conserve and where practical enhance the designated interest of nationally designated nature conservation sites. Maintain/achieve favourable condition.				Habitat creation
To avoid adverse impacts on, conserve and where practical enhance national and local BAP habitats.				Habitat creation
To support natural processes and maintain geological exposures throughout nationally designated geological sites.				
To conserve and enhance nationally designated landscapes in relation to risks from coastal flooding and erosion and avoid conflict with AONB and National Park Management Plan Objectives.				Appropriate design
To minimise coastal flood and erosion risk to scheduled and other internationally and nationally important cultural heritage assets, sites and their setting.				Excavation and recording
To minimise the impact of policies on marine operations and activities.				Monitoring and appropriate design
To minimise coastal flood and erosion risk to critical infrastructure and maintain critical services.				Relocation or realignment
To minimise coastal flood and erosion risk to agricultural land and horticultural activities.				
To minimise coastal flood and erosion risk to people and residential property.				
To minimise coastal flood and erosion risk to key community, recreational and amenity facilities.				
To minimise coastal flood and erosion risk to industrial, commercial, economic and tourism assets and activities.				Relocation

Examine opportunities for habitat creation in the area of Morfa Bychan.

This table provides a summary of the SEA (appendix E) and reference should be made to the Appendix for full details of the assessment.

These next two sections provide a headline summary of the findings of the HRA (Appendix G) and the WFA (Appendix H). Reference should be made as appropriate to these Appendices for full details.

HRA SUMMARY

Anticipated Habitat Loss in PDZ 12 as a result of SMP Policy

Designated Site	PU	Habitat Type	Extent of Loss of Habitat (ha)			
			Epoch 1	Epoch 2	Epoch 3	Total
Llŷn Peninsula and the Sarnau SAC	12.13	Intertidal sandflat of which	0.00	6.01	18.00	24.01
	12.13	Saltmarsh	0.00	3.00	9.00	12.00
	12.14	Intertidal sandflat of which	0.00	0.30	1.56	1.85
	12.14	Saltmarsh	0.00	0.01	0.08	0.09

Pen Llŷn a`r Sarnau/ **Llŷn Peninsula** *and the Sarnau SAC:* It is concluded that there would be an **adverse effect on the integrity** of the intertidal habitat (sandflat and saltmarsh) within the boundary of the SAC as a result of the SMP2 policies. There will however, be **no adverse effect on the integrity** of the other SAC features.

Morfa Harlech a Morfa Dyffryn SAC: **no adverse effect on the integrity of the SAC**.

Coedydd Derw a Safleoedd Ystlumod Meirion/ Meirionnydd Oakwoods and Bat Sites SAC: **no adverse effect on the integrity of the SAC**.

Preventative/mitigation measures: Potentially move defences landward where possible where feasible to allow mudflats to roll back in time with sea level rise.

Risks/Assumptions: The habitat loss is considered precautionary, and where any works are to be undertaken detailed study would provide an accurate identification of whether habitat would be lost and the extent. Potentially, given the worst case assumptions, further detail of the likely actions and site specific study may conclude no habitat loss, given the worst case scenario used in this assessment. The areas of potential habitat loss are relatively large, and this is exacerbated by the fact that such low lying areas would show a large scale change, but this does not take into account accretion of sediments within the estuary or how inundation of areas north of the Cob would influence the development of intertidal sandflat and saltmarsh. Consequently, the assumptions used to determine loss are expected to have resulted in much greater extents of habitat loss than would occur.

SUMMARY CONCLUSION FROM THE WATER FRAMEWORK ASSESSMENT

Water body (and relevant PDZ)	**Environmental Objectives met?**				**WFD Summary Statement required?**	**Achievement of Any South East RBMP Mitigation Measures?**	**Details on how the specific South East RBMP Mitigation Measures have been attained** (dark green = achieved; light green = partly achieved & red = not achieved)
	WFD 1	**WFD2**	**WFD3**	**WFD4**			
Glaslyn (Transitional) (PDZ part 12) (MAN 27 and 28)	N/A	**x** **(PDZ 12)**	✓	✓	**Yes** – Environmental Objective WFD2 may not be met because of the SMPs policy in PDZ12 (MAN 28).	There were no relevant measures to the SMP2 for this water body.	N/A
Tremadog Bay (Coastal) (PDZ part 12, part 13) (MAN part 26, 27, 28, 29, 30, 31, 32 and part 33)	N/A	✓	✓	✓	**No** - not necessary as delivery of the WFD Environmental Objectives will not be prevented by the SMP policies and in some cases will ensure they are of benefit.	There were no relevant measures to the SMP2 for this water body.	N/A

Water body (including the PUs that affect it)	**WFD Summary Statement checklist**	**A brief description of decision making and reference to further documentation within the SMP**
Glaslyn (Transitional – T10) **PU12.13 & 12.14** (WFD 2)	**Mitigation measures:** have all practicable mitigation measures been incorporated into the preferred SMP policies that affect this water body in order to mitigate the adverse impacts on the status of the water body? If not, then list mitigation measures that could be required.	**RBMP mitigation measures incorporated into SMP policies:** • There were no mitigation measures in the Western Wales RBMP for this transitional water body. **Other potential mitigation measures that could be required:** • Management of the defences upstream of the Cob need to be examined further, which is also indicated in the North West Wales CFMP. • Investigate the possibility of raising the road between Porthmadog and Borth-y-Gest where necessary with a bridged section or re-routing it around to the east.

Water body (including the PUs that affect it)	WFD Summary Statement checklist	A brief description of decision making and reference to further documentation within the SMP
	Other issues: Can it be shown that there are no other over-riding issues that should be considered (e.g. designated sites, recommendations of the Appropriate Assessment)?	This water body includes and is adjacent to a number of designations, including three Natura 2000 sites: **Llŷn Peninsula** and the Sarnau SAC, Meirionnydd Oakwoods and Bat Sites SAC, Morfa Harlech a Morfa Dyffryn SAC and two SSSIs – the Morfa Harlech SSSI and Glaslyn SSSI. The Habitats Regulations Assessment concluded that there would be No Adverse Effect on the Morfa Harlech a Morfa Dyffryn SAC and Meirionnydd Oakwoods and Bat Sites SAC. However, the HTL would cause an adverse effect on the intertidal sandflats and saltmarsh of the **Llŷn Peninsula** and the Sarnau SAC as a result of coastal squeeze. There is a conflict of interest here, as maintaining the Cob Embankment protects a significant area of freshwater habitat whilst it prevents the natural morphology and hydrology of the estuarine water body and associated BQEs. .

Location reference:	**Criccieth East and Eastern Shingle Banks**
Management Area reference:	**M.A. 29**
Policy Development Zone:	PDZ12

* Note: Predicted shoreline mapping is based on a combination of monitoring data, analysis of historical maps and geomorphological assessment with allowance for sea level rise. Due to inherent uncertainties in predicting future change, these predictions are necessarily indicative. For use beyond the purpose of the shoreline management plan, reference should be made to the baseline data.

The following descriptions are provided to assist interpretation of the map shown overleaf.

100 year shoreline position:
The following maps aim to summarise the anticipated position of the shoreline in 100 years under the two scenarios of "With Present Management" and under the "Draft Preferred Policy" being put forward through the Shoreline Management Plan.

- In some areas the preferred policy does not change from that under the existing management approach. In some areas where there are hard defences this can be accurately identified. In other areas there is greater uncertainty. Even so, where the shoreline is likely to be quite clearly defined by a change such as the crest of a cliff the estimated position is shown as a single line.

- Where there is a difference between With Present Management and the Draft Preferred Policy this distinction is made in showing two different lines:

  With Present Management.
  Draft Preferred Policy.

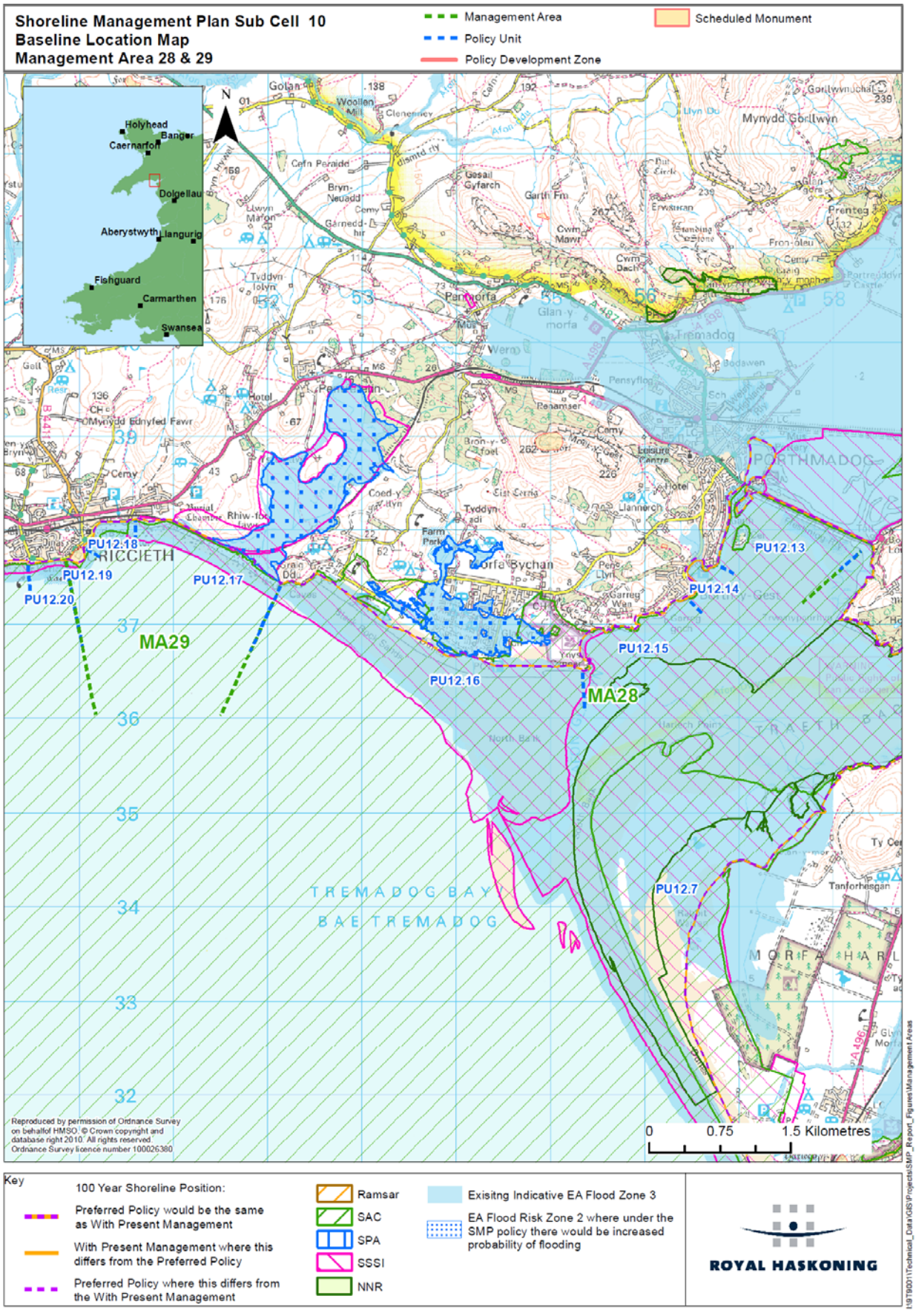
Flood Risk Zones

General Flood Risk Zones. The explanation of these zones is provided on the Environment Agency's web site www.environment-agency.gov.uk. The maps within this Draft SMP document show where SMP policy might influence the management of flood risk.

Indicate areas where the intent of the SMP draft policy is to continue to manage this risk.

Indicate where over the 100 years the policy would allow increased risk of flooding.

The maps should be read in conjunction with the text within the Draft SMP document.


Shoreline Management Plan Sub Cell 10
Baseline Location Map
Management Area 28 & 29
Management Area
Policy Unit
Policy Development Zone
Scheduled Monument
Holyhead
Bangor
Caernarfon
Dolgellau
Aberystwyth
Llanguric
Fishguard
Carmarthen
Swansea
N
PU12.18
PU12.19
PU12.20
PU12.17
PU12.13
PU12.14
PU12.15
PU12.16
PU12.7
MA29
MA28
TREMADOG BAY
BAE TREMADOG
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0
0.75
1.5 Kilometres
Key
100 Year Shoreline Position:
Preferred Policy would be the same as With Present Management
With Present Management where this differs from the Preferred Policy
Preferred Policy where this differs from the With Present Management
Ramsar
SAC
SPA
SSSI
NNR
Exisitng Indicative EA Flood Zone 3
EA Flood Risk Zone 2 where under the SMP policy there would be increased probability of flooding
ROYAL HASKONING

SUMMARY OF PREFERRED PLAN RECOMMENDATIONS AND JUSTIFICATION

INTENT OF THE PLAN:

The intent of the plan is to maintain the important seafront and harbour area of Criccieth. With sea level rise this may mean a degree of realignment to sustain the main area of defences, potentially increasing the influence of the harbour structure and realigning the groyne structure at the eastern end.

To the east, maintaining the natural single beach would become increasingly difficult with sea level rise without reinforcing the natural defence as a full rock revetment and embankment. As the shingle bank moves back, the central headland would become more prominent. While the option for realignment of the railway line should be considered, it may be possible to increase the overall control of the frontage in such a manner that the shingle bank would still continue to provide adequate defence. This would depend on the level of the railway line. The intent of the plan would be not to continue to provide any significant flood defence to the main valley of Ystumllyn beyond that necessary to sustain the railway. Any change in management at the central headland would need to be considered in relation to management at Criccieth. The increased flooding within the valley may provide opportunity for habitat creation.

KEY ISSUES/RISK AND UNCERTAINTY:

There are uncertainties in terms of timing of the proposed changes. There is also a need for a detailed planned response to change. It will be important to related this to national monitoring of sea level rise and more general climate change.

There are potential issues over funding of management at Criccieth and in examining the significant amenity value of the frontage there may be opportunity for collaborative funding in support of future works.

ACTIONS:

ACTION	PARTNERS	
Shoreline monitoring	**GC**	
Develop a management strategy for the whole area	**GC** **Communities** **Network rail**	 **Highways** **EA**
Assess opportunity for habitat creation	**EA**	**CCW**

DELIVERY OF THE PLAN

SUMMARY OF SPECIFIC POLICIES

Policy Unit		Policy Plan			
		2025	2055	2105	Comment
12.17	Criccieth Shingle Banks	HTL	MR	MR	Consideration of potential to realign the railway
12.18	Criccieth Harbour	HTL	HTL	MR	Look to realign the shoreline to the frontage through development of the Harbour pier and eastern end of The Esplanade to retain the beach.
12.19	Castle Headland	NAI	NAI	NAI	
Key: HTL - Hold the Line, A - Advance the Line, NAI – No Active Intervention MR – Managed Realignment					

PREFERRED POLICY TO IMPLEMENT PLAN:	
From present day	Maintain existing defences. Develop a long term strategic approach
Medium term	Maintain defences while moving towards adaptive management
Long term	Maintain defences.

IMPLICATIONS OF THE PLAN

CHANGES FROM PRESENT MANAGEMENT

The overall intent of management does not change but the approach to managing the defence line should look at medium to long term realignment to maintain defence to important assets.

ECONOMIC SUMMARY

Economics (£k PV)	by 2025	by 2055	by 2105	Total £k PV
NAI Damages	0.0	173.0	454.0	627.0
Preferred Plan Damages	0.0	0.0	0.0	0.0
Benefits	0.0	173.0	454.0	627.0
Costs	0.0	803.4	109.7	913.2

FLOOD AND EROSION RISK MANAGMENT

POTENTIAL LOSS

There are no losses indicated from the SMP, although there could be an increased risk of wave overtopping.

BENEFITS OF THE PLAN

The plan provides a longer term sustainable approach to defence, maintaining defence to the core community areas and the railway line. The plan provides protection to some 41 properties at risk from erosion. Flood damage due to wave overtopping has not been assessed but the plan aims to maintain levels of defence by enhancing protection and sustaining beach levels.

SUMMARY OF STRATEGIC ENVIRONMENTAL ASSESSMENT (INCLUDING HRA)

PDZ 12				
SEA Objective	**Impact of Preferred Policy for each Epoch**			
	1	**2**	**3**	**Mitigation**
Policy Units 12.1 to 12.25				
To support natural processes, maintain and enhance the integrity of internationally designated nature conservation sites. Maintain / achieve favourable condition of their interest features (habitats and species).				Habitat creation
To avoid adverse impacts on, conserve and where practical enhance the designated interest of nationally designated nature conservation sites. Maintain/achieve favourable condition.				Habitat creation
To avoid adverse impacts on, conserve and where practical enhance national and local BAP habitats.				Habitat creation
To support natural processes and maintain geological exposures throughout nationally designated geological sites.				
To conserve and enhance nationally designated landscapes in relation to risks from coastal flooding and erosion and avoid conflict with AONB and National Park Management Plan Objectives.				Appropriate design
To minimise coastal flood and erosion risk to scheduled and other internationally and nationally important cultural heritage assets, sites and their setting.				Excavation and recording
To minimise the impact of policies on marine operations and activities.				Monitoring and appropriate design
To minimise coastal flood and erosion risk to critical infrastructure and maintain critical services.				Relocation or realignment
To minimise coastal flood and erosion risk to agricultural land and horticultural activities.				
To minimise coastal flood and erosion risk to people and residential property.				
To minimise coastal flood and erosion risk to key community, recreational and amenity facilities.				
To minimise coastal flood and erosion risk to industrial, commercial, economic and tourism assets and activities.				Relocation

Examine opportunities for habitat creation within the Llyn Ystumllyn valley

This table provides a summary of the SEA (appendix E) and reference should be made to the Appendix for full details of the assessment.

These next two sections provide a headline summary of the findings of the HRA (Appendix G) and the WFA (Appendix H). Reference should be made as appropriate to these Appendices for full details.

HRA SUMMARY

Anticipated Habitat Loss in PDZ 12 as a result of SMP Policy

Designated Site	PU	Habitat Type	Extent of Loss of Habitat (ha)			
			Epoch 1	Epoch 2	Epoch 3	Total
Llŷn Peninsula and the Sarnau SAC	12.17	Intertidal sandflat (with shingle / pebbles)	0.00			0.00
	12.18	Intertidal sandflat (with shingle / pebbles)	0.00	0.30		0.30

Pen Llŷn a`r Sarnau/ **Llŷn Peninsula** *and the Sarnau SAC:* It is concluded that there would be an **adverse effect on the integrity** of the intertidal habitat (sandflat and saltmarsh) within the boundary of the SAC as a result of the SMP2 policies. There will however, be **no adverse effect on the integrity** of the other SAC features.

Morfa Harlech a Morfa Dyffryn SAC: **no adverse effect on the integrity of the SAC**.

Coedydd Derw a Safleoedd Ystlumod Meirion/ Meirionnydd Oakwoods and Bat Sites SAC: **no adverse effect on the integrity of the SAC**.

Preventative/mitigation measures: Potentially move defences landward where possible where feasible to allow mudflats to roll back in time with sea level rise.

Risks/Assumptions: The habitat loss is considered precautionary, and where any works are to be undertaken detailed study would provide an accurate identification of whether habitat would be lost and the extent. Potentially, given the worst case assumptions, further detail of the likely actions and site specific study may conclude no habitat loss, given the worst case scenario used in this assessment. The areas of potential habitat loss are relatively large, and this is exacerbated by the fact that such low lying areas would show a large scale change, but this does not take into account accretion of sediments within the estuary or how inundation of areas north of the Cob would influence the development of intertidal sandflats and saltmarsh. Consequently, the assumptions used to determine loss are expected to have resulted in much greater extents of habitat loss than would occur.

SUMMARY CONCLUSION FROM THE WATER FRAMEWORK ASSESSMENT

Water body (and relevant PDZ)	**Environmental Objectives met?**				**WFD Summary Statement required?**	**Achievement of Any South East RBMP Mitigation Measures?**	**Details on how the specific South East RBMP Mitigation Measures have been attained** (dark green = achieved; light green = partly achieved & red = not achieved)
	WFD 1	**WFD2**	**WFD3**	**WFD4**			
Tremadog Bay (Coastal) (PDZ part 12, part 13) (MAN part 26, 27, 28, 29, 30, 31, 32 and part 33)	N/A	✓	✓	✓	**No** - not necessary as delivery of the WFD Environmental Objectives will not be prevented by the SMP policies and in some cases will ensure they are of benefit.	There were no relevant measures to the SMP2 for this water body.	N/A

Location reference:	**Criccieth West**
Management Area reference:	**M.A. 30**
Policy Development Zone:	PDZ12

* Note: Predicted shoreline mapping is based on a combination of monitoring data, analysis of historical maps and geomorphological assessment with allowance for sea level rise. Due to inherent uncertainties in predicting future change, these predictions are necessarily indicative. For use beyond the purpose of the shoreline management plan, reference should be made to the baseline data.

The following descriptions are provided to assist interpretation of the map shown overleaf.

100 year shoreline position:
The following maps aim to summarise the anticipated position of the shoreline in 100 years under the two scenarios of "With Present Management" and under the "Draft Preferred Policy" being put forward through the Shoreline Management Plan.

- In some areas the preferred policy does not change from that under the existing management approach. In some areas where there are hard defences this can be accurately identified. In other areas there is greater uncertainty. Even so, where the shoreline is likely to be quite clearly defined by a change such as the crest of a cliff the estimated position is shown as a single line.

- Where there is a difference between With Present Management and the Draft Preferred Policy this distinction is made in showing two different lines:

  With Present Management.
  Draft Preferred Policy.

Flood Risk Zones

General Flood Risk Zones. The explanation of these zones is provided on the Environment Agency's web site www.environment-agency.gov.uk. The maps within this Draft SMP document show where SMP policy might influence the management of flood risk.

Indicate areas where the intent of the SMP draft policy is to continue to manage this risk.

Indicate where over the 100 years the policy would allow increased risk of flooding.

The maps should be read in conjunction with the text within the Draft SMP document.


Shoreline Management Plan Sub Cell 10
Baseline Location Map
Management Area 30
Management Area
Policy Unit
Policy Development Zone
Scheduled Monument
Holyhead
Bangor
Caernarfon
Dolgellau
Aberystwyth
Llanguric
Fishguard
Carmarthen
Swansea
N
PU12.18
PU12.19
PU12.17
PU12.20
PU12.21
PU12.22
PU12.23
PU12.24
PU12.25
PU13.1
MA29
MA30
Llanystumdwy
Chwilog
Criccieth
Afon Wen
0
0.75
1.5 Kilometres
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Key
100 Year Shoreline Position:
Preferred Policy would be the same as With Present Management
With Present Management where this differs from the Preferred Policy
Preferred Policy where this differs from the With Present Management
Ramsar
SAC
SPA
SSSI
NNR
Exisitng Indicative EA Flood Zone 3
EA Flood Risk Zone 2 where under the SMP policy there would be increased probability of flooding
ROYAL HASKONING

SUMMARY OF PREFERRED PLAN RECOMMENDATIONS AND JUSTIFICATION

INTENT OF THE PLAN:

Key sections of the shoreline within this area are Criccieth West, the Dwyfor and at Afon Wen. At Criccieth the intent of the plan is to continue defence of this area of the town. This has a strong economic justification in terms of erosion risk, and despite the depleted beach and increased wave action, defence of this area is viewed as being sustainable. There would need to be some transitional management between this section and the coast to the west where the intent is to allow the shoreline to erode back. Along the frontage there are properties at risk due to the slow rate of erosion. This frontage does continue to supply sediment to Criccieth and any private action to defend would probably need to be time limited and to demonstrate that there would be no detrimental impact in terms of defence elsewhere.

This general intent to allow erosion to the back shore and to allow natural development of the shoreline extends all the way through to the Afon Wen. There is a short section of flood defence within this section where there would be no longer any intent to maintain the defence. As such, the policy is also to allow flooding to occur within the Dwyfor Valley and this has implications with respect to the railway line and potentially to properties. There may be case for local set back defence.

At Afon Wen continued defence of the railway would involve extension and significant reinforcing of the defence against toe erosion and wave attack. This would further impact on the geological designated site to the east and would mean that the railway relied more and more on continued reinforcing the defence. While alternative approaches to defence may be feasible in the long term, considering the potential impact on the railway at the Afon Dwyfor and in other areas along the Llŷn coastline, realignment of the railway may be a more acceptable and sustainable approach. The present approach for a linear defence is considered unsustainable and as such the aim of the plan would be for realignment along this frontage.

KEY ISSUES/RISK AND UNCERTAINTY:

There are uncertainties in terms of timing of the proposed changes. There is also a need for a detailed planned response to change. It will be important to relate this to national monitoring of sea level rise and more general climate change.
There needs to be a full review of management of the railway line covering this area and MA 31 covered in the following PDZ.

ACTIONS:

ACTION	PARTNERS	
Shoreline monitoring	**GC**	
Review of defence of the railway line	**Network Rail** **GC** **CCW**	**WAG** **Highways** **EA**
Assess in detail potential impact on historic environment	**CADW**	
Examine potential for habitat creation within the Wen and Dwyfor valleys	**EA**	**CCW**

DELIVERY OF THE PLAN

SUMMARY OF SPECIFIC POLICIES

Policy Unit		Policy Plan			
		2025	2055	2105	Comment
12.20	Criccieth West	HTL	HTL	HTL	.
12.21	Y Dryll	NAI	NAI	NAI	
12.22	Dwyfor	MR	NAI	NAI	Consider impact on railway
12.23	Glanllynnau Cliffs	NAI	NAI	NAI	Maintain geological exposure
12.24	Afon Wen	HTL	MR	MR	Concerns over long term sustainability. Consider possible realignment in land of the railway.
12.25	Pen ychain east	NAI	NAI	NAI	This might not preclude local private management of defences subject to normal approvals.
Key: HTL - Hold the Line, A - Advance the Line, NAI – No Active Intervention MR – Managed Realignment					

PREFERRED POLICY TO IMPLEMENT PLAN:	
From present day	Maintain existing defences with the exception of that to the Afon Dwyfor. Review defence management to the railway.
Medium term	Maintain defences while moving towards adaptive management at Afon Wen. Potential realignment of the railway.
Long term	Maintain and improve defence at Criccieth.

IMPLICATIONS OF THE PLAN

CHANGES FROM PRESENT MANAGEMENT

At

ECONOMIC SUMMARY

Economics (£k PV)	by 2025	by 2055	by 2105	Total £k PV
NAI Damages	0.3	636.9	701.3	1,338.5
Preferred Plan Damages	0.3	2.9	52.4	55.6
Benefits	0.0	634.0	648.9	1,282.9
Costs	0.0	2,311.8	699.8	3,011.6

This assessment does not take account of potential realignment of the railway.

FLOOD AND EROSION RISK MANAGMENT

POTENTIAL LOSS

There could be loss of potentially two properties due to erosion.

BENEFITS OF THE PLAN

The plan provides a longer term sustainable approach to defence, maintaining defence to the core community areas. The plan would continue defence to 60 properties at Criccieth.

SUMMARY OF STRATEGIC ENVIRONMENTAL ASSESSMENT (INCLUDING HRA)

PDZ 12				
SEA Objective	**Impact of Preferred Policy for each Epoch**			
	1	**2**	**3**	**Mitigation**
Policy Units 12.1 to 12.25				
To support natural processes, maintain and enhance the integrity of internationally designated nature conservation sites. Maintain / achieve favourable condition of their interest features (habitats and species).				Habitat creation
To avoid adverse impacts on, conserve and where practical enhance the designated interest of nationally designated nature conservation sites. Maintain/achieve favourable condition.				Habitat creation
To avoid adverse impacts on, conserve and where practical enhance national and local BAP habitats.				Habitat creation
To support natural processes and maintain geological exposures throughout nationally designated geological sites.				
To conserve and enhance nationally designated landscapes in relation to risks from coastal flooding and erosion and avoid conflict with AONB and National Park Management Plan Objectives.				Appropriate design
To minimise coastal flood and erosion risk to scheduled and other internationally and nationally important cultural heritage assets, sites and their setting.				Excavation and recording
To minimise the impact of policies on marine operations and activities.				Monitoring and appropriate design
To minimise coastal flood and erosion risk to critical infrastructure and maintain critical services.				Relocation or realignment
To minimise coastal flood and erosion risk to agricultural land and horticultural activities.				
To minimise coastal flood and erosion risk to people and residential property.				
To minimise coastal flood and erosion risk to key community, recreational and amenity facilities.				
To minimise coastal flood and erosion risk to industrial, commercial, economic and tourism assets and activities.				Relocation

rates.

This table provides a summary of the SEA (appendix E) and reference should be made to the Appendix for full details of the assessment.

These next two sections provide a headline summary of the findings of the HRA (Appendix G) and the WFA (Appendix H). Reference should be made as appropriate to these Appendices for full details.

HRA SUMMARY

Anticipated Habitat Loss in PDZ 12 as a result of SMP Policy

Designated Site	PU	Habitat Type	Extent of Loss of Habitat (ha)			
			Epoch 1	Epoch 2	Epoch 3	Total
Llŷn Peninsula and the Sarnau SAC	12.20	Intertidal pebble and shingle beach	0.00	0.82	0.12	0.94
	12.24	Intertidal sandflat	0.00			0.00

Pen Llŷn a`r Sarnau/ **Llŷn Peninsula** *and the Sarnau SAC:* It is concluded that there would be an **adverse effect on the integrity** of the intertidal habitat (sandflat and saltmarsh) within the boundary of the SAC as a result of the SMP2 policies. There will however, be **no adverse effect on the integrity** of the other SAC features.

Morfa Harlech a Morfa Dyffryn SAC: **no adverse effect on the integrity of the SAC**.

Coedydd Derw a Safleoedd Ystlumod Meirion/ Meirionnydd Oakwoods and Bat Sites SAC: **no adverse effect on the integrity of the SAC**.

Preventative/mitigation measures: Potentially move defences landward where possible, where feasible to allow mudflats to roll back in time with sea level rise.
Within the Morfa Harlech a Morfa Dyffryn SAC suggested mitigation measures may be to explore integrated management of the dunes as a whole to allow the body of the sand to migrate landward to maintain the dune system and their relevant position to the tidal frame.

Risks/Assumptions: The habitat loss is considered precautionary, and where any works are to be undertaken detailed study would provide an accurate identification of whether habitat would be lost and the extent. Potentially, given the worst case assumptions, further detail of the likely actions and site specific study may conclude no habitat loss, given the worst case scenario used in this assessment. The areas of potential habitat loss are relatively large, and this is exacerbated by the fact that such low lying areas would show a large scale change, but this does not take into account accretion of sediments within the estuary or how inundation of areas north of the Cob would influence the development of intertidal sandflats and saltmarsh. Consequently, the assumptions used to determine loss are expected to have resulted in much greater extents of habitat loss than would occur.

SUMMARY CONCLUSION FROM THE WATER FRAMEWORK ASSESSMENT

Water body (and relevant PDZ)	**Environmental Objectives met?**				**WFD Summary Statement required?**	**Achievement of Any South East RBMP Mitigation Measures?**	**Details on how the specific South East RBMP Mitigation Measures have been attained** (dark green = achieved; light green = partly achieved & red = not achieved)
	WFD 1	**WFD2**	**WFD3**	**WFD4**			
Dwyfor (Transitional) (PDZ part 12) (MAN part 30)	N/A	✓	✓	✓	**No** - not necessary as delivery of the WFD Environmental Objectives will not be prevented by the SMP policies and in some cases will ensure they are a benefit.	There were no relevant measures to the SMP2 for this water body.	N/A
Tremadog Bay (Coastal) (PDZ part 12, part 13) (MAN part 26, 27, 28, 29, 30, 31, 32 and part 33)	N/A	✓	✓	✓	**No** - not necessary as delivery of the WFD Environmental Objectives will not be prevented by the SMP policies and in some cases will ensure they are of benefit.	There were no relevant measures to the SMP2 for this water body.	N/A