

ANNEX D

Re-building Welsh Beaches to Deliver Multiple Benefits

Work Package 3 – Resource Study and Economic Appraisal



Contract No: 249 MFG 10

Winnard, K; McCue, J; Pye, K.

**Re-building Welsh Beaches to Deliver
Multiple Benefits**

**ANNEX D, Work Package 3 –
Resource Study and Economic Appraisal**

Final Report

April 2011

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The project represents the findings of a feasibility study commissioned by CCW to explore the potential opportunities and constraints associated with beach re-building in Wales. It does not set out any policy position for ALFW or members of the Steering Group, and does not imply a commitment to funding with respect to recommendations set out.

Re-Building Welsh Beaches to Deliver Multiple Benefits. Annex D- Work Package 3 – Resource Study and Economic Appraisal

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Author(s): **Winnard, K; McCue, J; Pye, K, Dearnaley, M**

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Re-Building Welsh Beaches to Deliver Multiple Benefits. Annex D- Work Package 3 – Resource Study and Economic Appraisal



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1 INTRODUCTION

A Steering Group comprising The Countryside Council for Wales (CCW), The Crown Estate, British Marine Aggregates Producers Association (BMAPA), Welsh Assembly Government, and the Environment Agency Wales (EAW) has been established to take forward a study relating to the use of aggregates for beach nourishment in Wales.

During 2009/2010 the Steering Group commissioned a Pilot Study to take forward the initial phase of work on this project which has been completed. The results of the Pilot Study were summarised in a report dated March 2010 (McCue et al., 2010). The Steering Group has now been awarded additional funds from the Aggregates Levy Fund for Wales, and are now progressing Phase 2 of the project, building upon the outputs and recommendations of the Pilot Study. Atkins Limited (Atkins) were contracted in November 2010 to take forward the additional works required for the project “*Beach nourishment operations in Wales and the likely future requirements for beach nourishment in an era of sea level rise and climate change – Phase 2*”.

This report represents contracted Deliverable 3 (Resource Study and Economic Appraisal). The report outlines the approach, findings and conclusions of the review as specified as part of this contract.

The purpose of this report is to determine the following:

- Review the supply side of beach nourishment, looking at the extent to which future management operations will be constrained by the lack of available materials, including:
 - The likely range of sediment types, quantities and locations of material required for Welsh beaches;
 - The properties of likely sources and how well they match with the requirements of Welsh beaches;
 - Extent of resources at current licensed sites;
 - Indication of resources from other areas (i.e. non-licensed areas);
- The overall cost framework, including costs of:
 - Materials;
 - Transport;
 - Extraction and placing of material by different methods;
 - Regulatory compliance (including the cost of obtaining a new aggregates license);
 - FEPA / Marine Act consent

The report also includes a review of the findings and their application to three case study beaches in Wales, namely:

- Abergele-Pensarn;
- Morfa Dyffryn;
- Trecco Bay, Porthcawl

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These beaches were chosen because they represent a selection of beach types and uses. Abergele-Pensarn was chosen as a candidate where the existing beach levels are low, backed by sea walls, and where beach nourishment could increase the flood defence value.

Morfa Dyffryn was chosen as a candidate where the beach is not particularly low, but backed by potentially erodible dunes, and where beach nourishment would additionally provide wind-blown nourishment of the dunes, thereby potentially increasing the nature conservation value.

Sandy Bay and Trecco Bay at Porthcawl were chosen as candidates where the beaches are vital local resources for leisure and tourism and an important economic asset to the town, and therefore where beach nourishment could increase the touristic and recreational value.

The range of different tasks that come together within this Work Package are summarised in Figure 1.1.

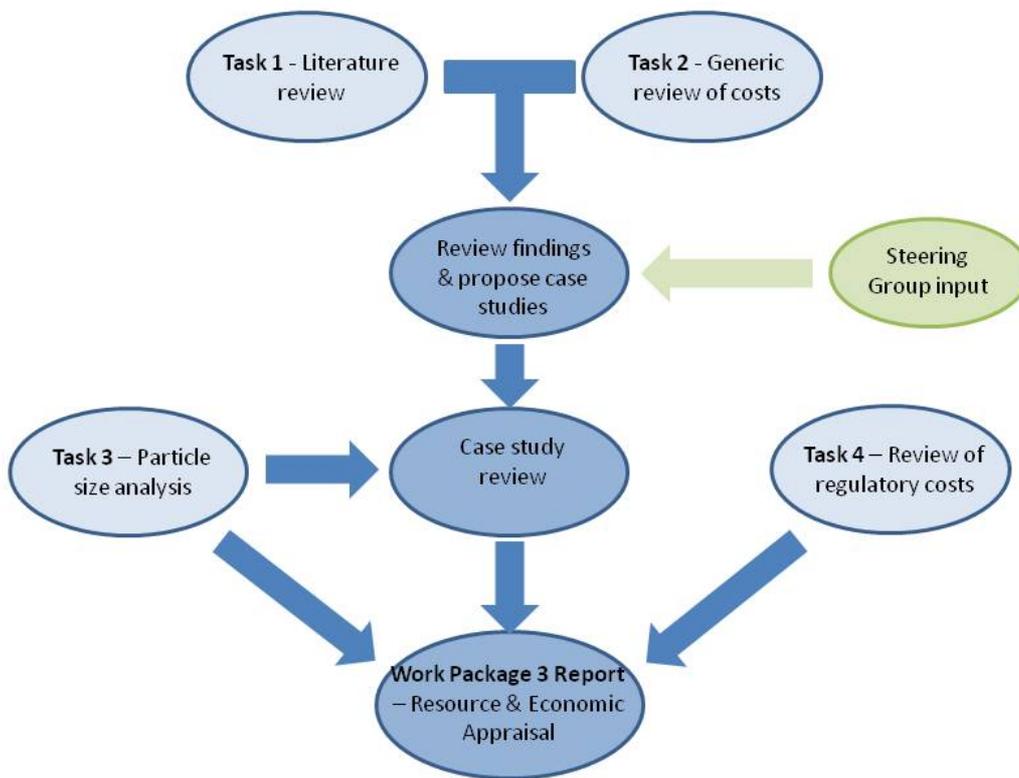


Figure 1.1 - Development of the Work Package

The findings of the review shall be used, along with findings from the other Work Packages to inform the final report, conclusions and recommendations. This report shall form an Appendix to the Final Report – “*Re-building Welsh Beaches to Deliver Multiple Benefits*”.

2 RESOURCES

This section of the report investigates the physical properties of the material on Welsh beaches to determine the types of material that would be needed to undertake beach nourishment around Wales.

The types of material that are readily available from marine aggregate sources are also investigated and compared to the types of sediment on Welsh beaches to determine if these sources are suitable for beach nourishment.

A number of feeder reports were produced by Ken Pye Associates Limited (KPAL) to inform this Work Package:

- Morphological and Sedimentological Character of Welsh Beaches – Classification Summary (Report IR1102);
- Particle Size Analysis (Report PS/54283);
- LiDAR Data Analysis (Report IR1123);
- Preliminary Comparison of Particle Size Characteristics of Marine Aggregates and Selected Welsh Case Study Beaches (Report IR1126) , and

These reports can be found in *Appendices A – D*.

2.1 Morphological and Sedimentological Character of Welsh Beaches

Beaches around Wales were initially identified using a combination of 1:25,000 Ordnance Survey maps and aerial photographs. A ‘beach’ in this context was defined as being composed of unconsolidated sediment which is exposed during a mean tidal cycle. Narrow accumulations at the base of cliffs composed largely of rock fall deposits were not included within the definition, and beach shorter than 100 metres in length were also excluded. Beaches were considered to be separate if they were isolated alongshore by natural or artificial headlands. Continuous beaches were also divided into separate units where the morphological classification changed significantly.

Beaches were then classified at a high level into the following three groups:

- ***Open coast*** - generally linear beaches, bounded by small rock headlands which allow some alongshore sediment transport around their foot. Such beaches are often exposed to relatively high energy waves generated over large fetches;
- ***Bay*** – this includes a number of very large bodies of water, such as St Brides Bay and Carmarthen Bay, and also much smaller embayments such as Port Eynon Bay on the Gower;
- ***Estuary*** - a relatively broad definition has been used that includes examples at the mouths of relatively large rivers (e.g. the Dee, Dovey, Loughor) as well as examples of inlets with limited freshwater input, such as Milford Haven, and straits such as Menai Straits.

A total of 215 beaches were initially identified. The location, classification and dimensions of the beaches are set out in the KPAL report in *Appendix A*.

2.1.1 Morphological classification

A five-fold classification has been used to define the ‘beach morphological type’:

- ***Barrier beach*** - a sediment accumulation lying approximately parallel to the coastline and seaward of the rising land. Either open water or low-lying marsh (sometimes reclaimed) may be present on the landward side of the barrier. A ‘barrier beach’ is defined where both ends of the beach adjoin high land. The land may drain either by percolation through the barrier, by way of an artificial weir, or via a narrow river or stream outlet;
- ***Barrier spit*** - only one end of the beach is attached to higher ground, often at the mouth of a large estuary;
- ***Barrier island*** - neither end of the beach is attached to higher ground (the Pembrey coastline is the only such example identified in Wales, although today it is virtually contiguous with land to the east as a result of reclamation);
- ***Fringing*** – beaches that are directly backed by rising land (either gently rising or cliffs);
- ***Pocket beach*** - the special case of small fringing beaches that occur within short (< 500m) rock-bound embayments.

Using this classification, over 50% of all beaches in Wales are classified as ‘fringing’ and, while there are many pocket beaches, they collectively represent less than 4% of beaches by length. There is only a single example of a barrier island in Wales, the Pembrey system, which is also the longest beach in Wales, and represents over 12% of the beach frontage length in Wales (see *Figure 2.2*).

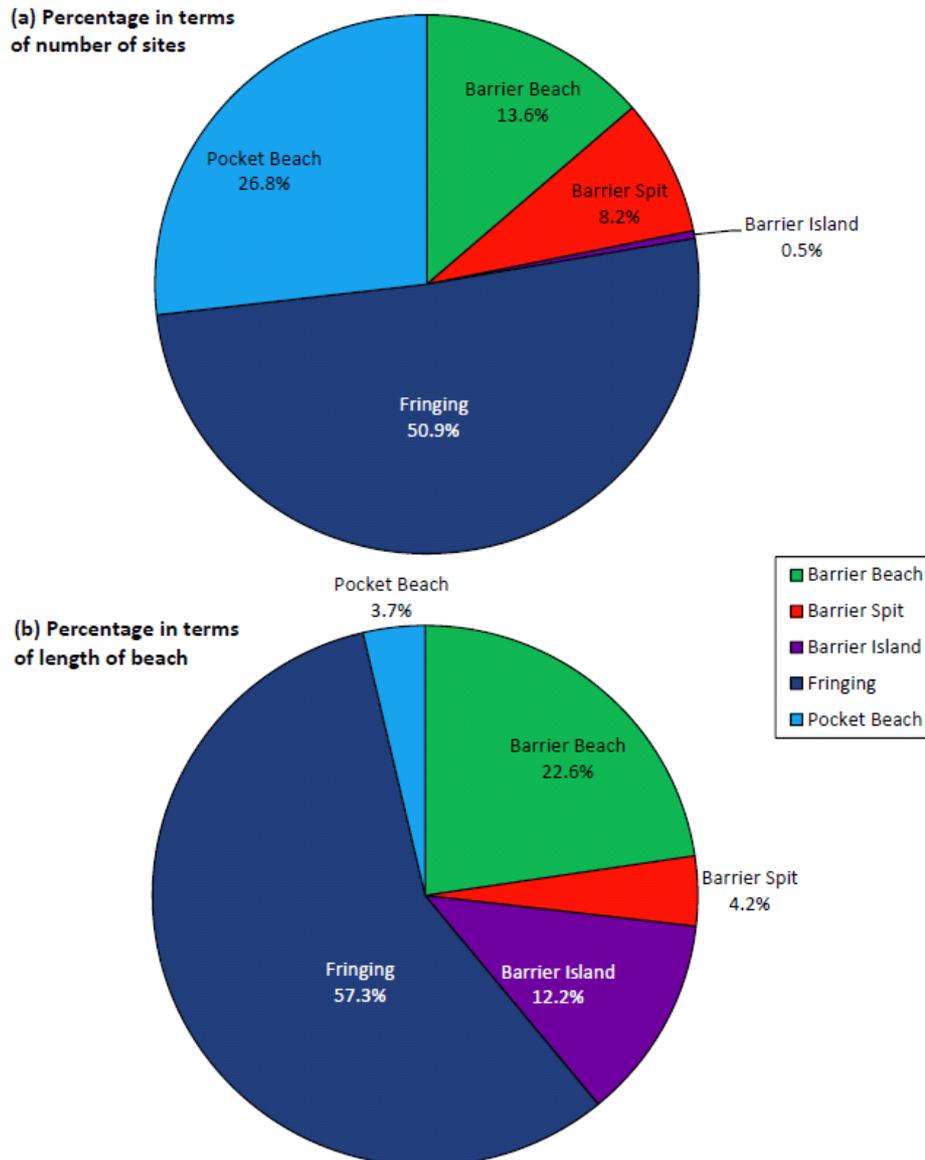


Figure 2.2 - Beach morphology types in Wales by a) number and b) length

2.1.2 Sediment classification

A combination of 1:25,000 Ordnance Survey maps, aerial photographs and field observations was used to identify the ‘sediment type’ of the upper and lower beach for each site. Seven distinct types of beach were identified in Wales:

- Shingle or boulder upper beach, with a sandy lower beach
- Shingle or boulder upper beach, with a rock platform on the lower foreshore
- Sand predominating on both the upper and lower beach
- Shingle or boulder upper beach, with a muddy lower beach
- Shingle or boulders predominating on both the upper and lower beach
- Rock platform on the upper foreshore, with sand exposed at low water

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(g) A very low beach, where the sea reaches artificial sea defences at high tide, but with a sandy lower beach

Beach type (a), with a shingle upper beach and sandy lower beach is the most common type of beach in Wales (42%), followed by beaches composed predominantly of sand alone (type (c), 28% by length) and then gravel dominated beaches (20% by length).

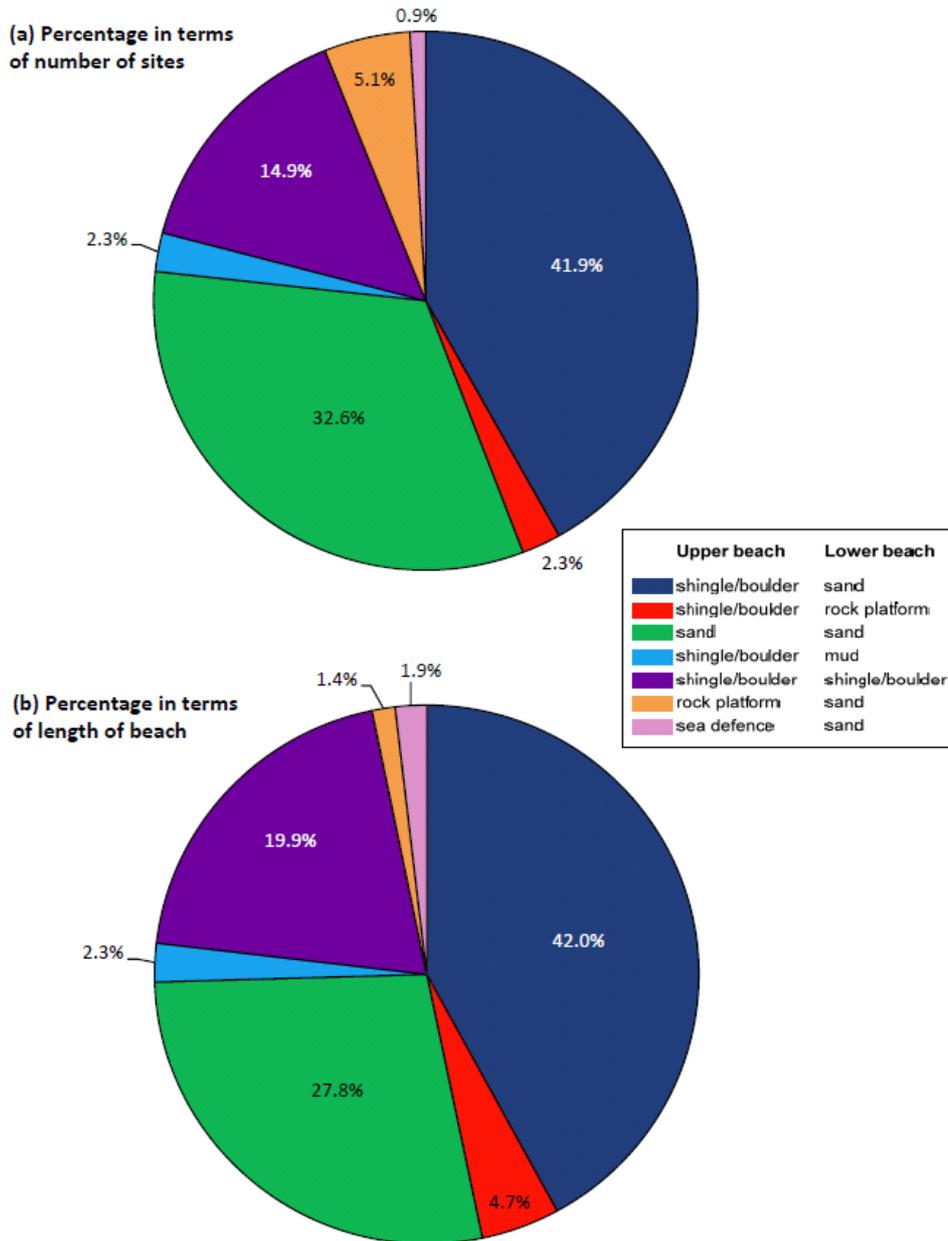


Figure 2.3 - Beach sediment types in Wales by a) number and b) length

Results of particle size analyses of 1,320 beach and offshore samples were provided by CCW under license (from Marine recorder 20101222, CCW RPSI licence ATI 598). Data were available at ‘whole phi’ intervals and were obtained by sieving. Beach samples were identified on the basis of their grid co-ordinates. Offshore samples were also identified where they were taken within or near to dredge licencing areas. The grain size distribution software program

GRADISTAT (Blott and Pye, 2001) was used to classify each sediment sample using its textural type, defined by Folk (1954). Results are set out in the KPAL report in *Appendix A*.

2.1.3 Particle size analysis

An analysis of sediment samples taken from the ten Pilot Study beaches was undertaken. Samples were taken from the upper, mid and lower beach at each site. A total of 60 samples were analysed.

Samples containing little or no gravel were dried and homogenised. Particle size analysis of the gravel fraction was determined by dry sieving on 300 mm diameter mesh sieves. Particle size analysis of the sand fraction was determined by dry sieving on 200 mm diameter mesh sieves. Where samples contained a significant quantity of mud, samples were initially wet sieved, and particle size analysis of the mud fraction performed by laser diffraction.

All data were exported to the GRADISTAT (Blott and Pye, 2001) computer program to calculate the sample statistics.

Full details of the methodology and instruments used and the results of the analysis of are set out in the KPAL report in *Appendix B*, including particle size grading curves.

2.2 Volume of Sediment Required for Beach Nourishment

As part of the Pilot Study, a preliminary assessment of the amount of sediment needed for beach nourishment was made using aerial photography and ground topographic survey data. For this Phase 2 work, Environment Agency LiDAR (**L**ight **D**etection and **R**anging) data was made available to allow a more detailed evaluation of required sediment volumes at three of the Pilot Study beaches.

2.2.1 Data analysis methodology

Data covering the 10 beaches from the Pilot Study were provided by the EA's Geomatics Group. Data was further processed using the Golden Software Surfer® program and visually by KPAL. For areas where data were missing, these were substituted using data from adjoining areas where appropriate. The backbeach area and floodable area behind the beach, lying below the level of Highest Astronomical Tide (HAT), was calculated for each site. In this case, "floodable" was defined as all areas which could be flooded to the level of HAT if any part of the beach frontage under consideration were hypothetically removed or breached.

To calculate the volume of sediment required for beach nourishment, two different design profiles were considered:

1. A flat-topped berm of sediment constructed seaward of the HAT level over a width of 20 m. To seaward of this, a sloping profile at a constant gradient of 1:25 until it intersects with the existing beach surface.
2. A flat-topped berm of sediment constructed seaward of the HAT level over a width of 20 m. To seaward of this, a sloping profile at a constant gradient (undefined angle) until it intersects with the existing beach surface at the mean sea level (MSL) contour.

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Estimates of sea level rise for each case study area and each Shoreline Management Plan review (SMP2) “epoch” (20, 50 and 100 years) were calculated using information downloaded from the UKCP09 website.

Values were obtained for three emissions scenarios (low, medium and high), representing the 5th, 50th and 90th percentile modelled values. The “minimum” expected sea level rise was taken to be the 5th percentile value for the low emissions scenario, while the “maximum” expected rise was taken to be the 95th percentile for the high emissions scenario. Values of up to 1.9 m of sea level rise have been considered possible but very unlikely by the UK Met Office, and therefore have not been considered for the purposes of the present report. A “best estimate” value for sea level rise was taken to be the 50th percentile value for the medium emissions scenario.

Each of these sea level rise increments was then multiplied by the beach areas calculated above to give an estimate of the volume fill requirement to maintain the existing beach form. It should be noted that these calculations provide an under-estimate of the actual volume of sediment that would need to be added to the beach since the volume fill calculations take no account of losses of nourished sediment which would inevitably occur and which would need to be compensated for in an actual “real life” scheme.

In order to estimate the volume of sediment that would be required to undertake an initial nourishment improvement scheme, and then to maintain it in the face of sea level rise and natural erosional losses, the initial nourishment requirements were used in conjunction with sea level rise estimates. The following assumptions were used in the calculations:

- An initial nourishment in 2010;
- Four subsequent five-yearly re-nourishments, each replacing an assumed 50% loss from the previous nourishment, and;
- Minimum, best estimate and maximum values for sea level rise by 2030. These amounts were then added to produce the total sediment volume requirements.

Full details of the methodology used to process the data and calculate volumes of sediment required are set out in the KPAL Report in *Appendix B*.

2.2.2 Results

Table 2.1 shows the planar areas of the defined possible nourishment areas (between HAT and MTL), and minimum, maximum and best estimates of volumes of sediment required to generate the two DSMs outlined above (i.e. 20m wide berm and 1 in 25 slope and 20m wide berm and slope down to MSL) until 2100. Intervals of 2030, 2060 and 2100 are used. Sea level rise is based on UKCP09 sea level rise predictions.

Minima represent the 5% values for the low emission (SRES B1) scenario, maxima represent the 95% values for the high emissions (A1FI) scenario, and best estimates represent the 50% values for the medium emissions (A1B) scenario. Increases are relative to 2010.

Calculations were made using available Environment Agency LiDAR data, but make no allowance for post-nourishment losses and re-nourishment required, and therefore underestimate the total volumes of sediment that would be required.

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Table 2.2 shows the nourishment volumes required until 2030 to generate the two DSMs outlined above (i.e. 20m wide berm and 1 in 25 slope and 20m wide berm and slope down to MSL), assuming an initial nourishment in 2010 followed by five-yearly renourishment campaigns to replace 50% losses, and additional volumes required to raise the beach profile due to sea level rise, based on minimum, maximum and best estimates from UKCP09 sea level rise predictions.

As before, minima represent the 5% values for the low emission (SRES B1) scenario, maxima represent the 95% values for the high emissions (A1FI) scenario, and best estimates represent the 50% values for the medium emissions (A1B) scenario. Calculations were made using available Environment Agency LiDAR data.

A brief description of the three case study areas and the results is given below. More detail of calculations, LiDAR analysis results, comparison with Digital Elevation Models (DEM) and cross-section beach profiles for the existing and nourishment DSMs are set out in the KPAL report in *Appendix C*.

Beach nourishment operations in Wales and likely future requirements for beach nourishment in an era of sea level rise and climate change – Phase 2. Work Package 3 – Resource Study and Economic Appraisal

Table 2.1 - Volumes of sediment required to maintain the design beach profiles to 2100 (no re-nourishment)

Site	Planar area of proposed nourishment (x10 ³ m ²)	Volumes of sediment required to maintain the existing beach profile (x10 ³ m ³)								
		Sea level rise by 2030 (cm)			Sea level rise by 2060 (cm)			Sea level rise by 2100 (cm)		
		Minimum	Best Estimate	Maximum	Minimum	Best Estimate	Maximum	Minimum	Best Estimate	Maximum
<i>Assuming 20 m wide berm and 1:25 slope to existing beach</i>										
2 Abergele-Pensarn	454	10	29	56	28	80	159	57	165	331
4 Morfa Dyffryn	375	9	24	47	25	68	134	52	140	277
10 Porthcawl: Sandy Bay	84	3	6	11	7	17	32	15	35	65
10 Porthcawl: Trecco Bay	131	4	10	18	12	26	49	23	54	101
<i>Assuming 20 m wide berm and slope to present MSL contour</i>										
2 Abergele-Pensarn	184	4	12	23	11	32	64	23	67	134
4 Morfa Dyffryn	656	16	43	83	45	119	234	90	245	485
10 Porthcawl: Sandy Bay	166	5	12	22	15	33	63	29	68	129
10 Porthcawl: Trecco Bay	130	4	10	18	12	26	49	23	54	101

Beach nourishment operations in Wales and likely future requirements for beach nourishment in an era of sea level rise and climate change – Phase 2. Work Package 3 – Resource Study and Economic Appraisal

Table 2.2 - Volumes of sediment required to maintain the design beach profiles to 2030 (with five-yearly re-nourishment)

Site	Initial nourishment (x10 ³ m ³)	Four renourishments assuming 50% losses every five years (x10 ³ m ³)	Volumes required to maintain existing beach profile (x10 ³ m ³)			Total volume of sediment required by 2030 (x10 ³ m ³)		
			Minimum	Best Estimate	Maximum	Minimum	Best Estimate	Maximum
<i>Assuming 20 m wide berm and 1:25 slope to existing beach</i>								
2 Abergele-Pensarn	846	1693	10	29	56	2549	2568	2595
4 Morfa Dyffryn	225	450	9	24	47	684	699	722
10 Porthcawl: Sandy Bay	85	170	3	6	11	258	261	266
10 Porthcawl: Trecco Bay	179	358	4	10	18	541	546	554
<i>Assuming 20 m wide berm and slope to present MSL contour</i>								
2 Abergele-Pensarn	268	537	4	12	23	809	817	828
4 Morfa Dyffryn	397	794	16	43	83	1208	1234	1274
10 Porthcawl: Sandy Bay	153	306	5	12	22	465	471	481
10 Porthcawl: Trecco Bay	171	342	4	10	18	517	522	530

Abergele - Pensarn Case Study Area

2004 LiDAR DEM compared with DEMs based on ground surveys in the spring and autumn of 2008 and 2009 show that the fundamental size and character of the beach has not changed significantly, although ridges and runnels on the foreshore have shown a tendency for progressive movement towards the east.

The westernmost part of the un-defended vegetated shingle beach ridge plain is currently eroding, and the upper active beach is both narrow and steep. Erosion threatens to undermine the flood wall which protects the caravan park and main North Wales Coast railway line in this area. Although most of the hinterland lies at a relatively high elevation, there is an area of relatively low-lying land behind the railway line through which stormwave overtopping could lead to flooding of the A55 coast road. Beach nourishment in this area therefore might be considered as an option to counter the current beach erosion trend, loss of vegetated shingle habitat, and reduce the flood risk to the transport infrastructure.

At the eastern end of the Abergele-Pensarn frontage the beach system acts as a key first line of defence against sea flooding of the low-lying hinterland much of which is occupied by bungalows and caravans. The beach in this area is currently wider and higher than further west. To the west of Pensarn station additional flood protection is provided by a wide promenade and car park, but to the east of the station there is only a narrow flood wall running very close to the railway line. Beach nourishment in this area would potentially provide a higher standard of flood protection than currently exists, would increase the area of dry beach available for recreational use, and would reduce the pressure on the areas of vegetated shingle priority habitat.

The largest volumes of imported sediment would be required at the western end of the beach system on account of the steep, narrow nature of the existing beach in this area. At the present time the upper and mid beach in this area are dominated by medium to coarse gravel, while the lower beach is composed mainly of fine to medium sand. Nourishment could be undertaken either using mixed sand and gravel, emplaced together and allowing natural processes to produce gradual particle size separation, or by separately placing gravel size material on the upper beach and sand on the lower beach.

Assuming an initial 20 m wide dry sand berm and 1 in 25 slope, an additional volume of sediment ranging from 10 to $331 \times 10^3 \text{ m}^3$ would be required to maintain this area under different projected conditions of sea level rise. With a 20 m wide berm and slope to the present mean sea level contour, the required sediment volumes would be much less (4 to $134 \times 10^3 \text{ m}^3$).

Considering only the next 20 years to 2030, and assuming a requirement for renourishment every 5 years of the initial sediment volume, assuming a 1 in 25 slope, between $2,549$ and $2,595 \times 10^3 \text{ m}^3$ of sediment would be required. For a 20 m wide berm and slope to the MSL contour, 809 to $828 \times 10^3 \text{ m}^3$ would be required.

Morfa Dyffryn Case Study Area

At Morfa Dyffryn beach nourishment could be considered as a potentially suitable method of enhancing the condition of the sand dune system (from a habitat conservation and biodiversity point of view), and also of providing improved defence from a coastal flooding and erosion risk management point of view.

The frontal dunes close to the main camping ground south of Shell Island and the Dyffryn Seaside Estate caravan park in the south experience heavy visitor pressure during the summer months, leading to degradation of the vegetation and extensive sand blowing. Especially in the

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northern area near Shell Island, the frontal dunes have extensive low points and there is a risk that, unless a higher, wider frontal dune ridge is developed, sea level rise will result in break through within the next 30 to 50 years.

Owing to the relatively high, wide nature of the beach, especially in the north, the cross-sectional areas and volumes per metre length of beach required for nourishment with a 1 in 25 slope are relatively small, but owing to the length of beach being considered for nourishment the total volumes of sediment required under different sea level rise scenarios are only slightly less than those required at Abergele - Pensarn.

Assuming a 20 m wide dry sand berm and slope to the MSL contour, the required volumes at Morfa Dyffryn are considerably larger (16 to $485 \times 10^3 \text{ m}^3$) than those at Abergele-Pensarn. If 50% losses and 5 yearly re-nourishment are assumed, the volumes of sediment required by 2030 range from 684 to $722 \times 10^3 \text{ m}^3$ with a 1 in 25 slope, and from $1,208$ to $1,274 \times 10^3 \text{ m}^3$ with a slope to the MSL contour.

At the southern end of the Morfa Dyffryn system the dune toe is protected against wave attack by an upper beach berm composed of medium to coarse gravel, derived largely from the outlet of the Afon Ysgethin to the south. Extension of this protective berm along the entire frontage would slow the rate of dune toe erosion in response to storms and sea level rise. Nourishment could therefore be undertaken either using a mixture of sand and medium to coarse gravel, or separately by placing coarse gravel on the upper beach and fine to medium sand on the lower beach. Aeolian processes are quite capable of transporting dry, fine to medium sand across areas of gravel upper beach to feed the dunes behind.

Porthcawl Case Study Area

The Porthcawl study area consist of two adjoining bays, Sandy Bay and Trecco Bay, which are bounded by rock headlands and an artificial former dock wall on the west side of Sandy Bay.

Both bays were formerly backed by an extensive area of sand dunes (Newton Burrows) which were largely destroyed by the development of static caravan parks in the late 1960's and 1970's. A small area of partially vegetated dunes remains at the eastern corner of Sandy Bay, but the western part is backed by a concrete wall along the seaward side of the Coney Island Amusement Park. Trecco Bay is now backed by rock armour and construction debris which provide erosion protection for the Trecco Bay caravan park, reputedly the largest such site in Europe.

Beach levels are now considerably higher in Sandy Bay than Trecco Bay, which has greater exposure to south-westerly waves. Sandy Bay is more attractive from a bathing and sun-bathing point of view, but Trecco Bay remains popular with surfers. Since much of the land behind the beach lies well above projected high tide levels, the main purpose of any beach nourishment in sandy bay and Trecco Bay would be to enhance the recreational and touristic value of the area. There would also be some added erosion protection value, especially in Trecco Bay.

The cross-sectional areas required for nourishment are considerably smaller in Sandy Bay than in Trecco Bay due to the higher, wider nature of the existing beach in Sandy Bay. The combined planar area considered for nourishment ($206 \times 10^3 \text{ m}^2$ assuming a 20 m wide berm and 1 in 25 slope) is smaller than both Abergele - Pensarn and Morfa Dyffryn.

The required sediment volume to maintain this area under projected sea level rise scenarios ranges from 7 to $166 \times 10^3 \text{ m}^3$, which is considerable less than the two other sites. Assuming a

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20 m wide dry sand berm and slope down to the MSL contour, the combined nourishment requirement under different sea level rise scenarios ranges from 9 to $230 \times 10^3 \text{ m}^3$.

If a 50% nourishment loss and replenishment every 5 years is assumed, between 799 and $820 \times 10^3 \text{ m}^3$ of sediment would be required to maintain the enhanced beach with 1 in 25 slope up to 2030. In the case of a 20 m berm plus slope to the MSL contour, between 982 and $1,011 \times 10^3 \text{ m}^3$ of sediment would be required. In order to preserve the present sedimentological character of the beach the vast majority of the sediment would need to consist of medium sand.

2.3 Suitability of Marine Aggregates for Beach Nourishment in Wales

A number of particle size grading curves were supplied by marine aggregate operators via the British Marine Aggregates Producers Association (BMAPA) from the following areas:

- Middle Ground, Severn Estuary (Dredge Area 385)
- Morecambe Bay (Dredge Area 331)
- Hilbre Swash (Dredge Area 392)
- Hoyle Bank

2.3.1 Data analysis methodology

Data have been reprocessed using the GRADISTAT particle size statistics package (Blott and Pye, 2001) and compared with the data for two of the case study beaches. Data from the South West aggregate sites (Middle Ground) were compared with Sandy Bay and Trecco Bay in South Wales, while data from the North West dredging area in the Irish Sea (Morecambe Bay, Hilbre Swash and Hoyle Bank) were compared with Abergele-Pensarn. This approach therefore compared data from the nearest marine aggregate extraction sites (see **Figure 2.4** – case study beach sites are identified in black; licensed dredging areas are identified in red).

Particle size curves for the offshore aggregate samples taken from Middle Ground were superimposed on those for the beach samples taken from Sandy Bay and Trecco Bay at Porthcawl, while those from Liverpool Bay and Morecambe Bay were superimposed on those taken from the Abergele-Pensarn case study site.

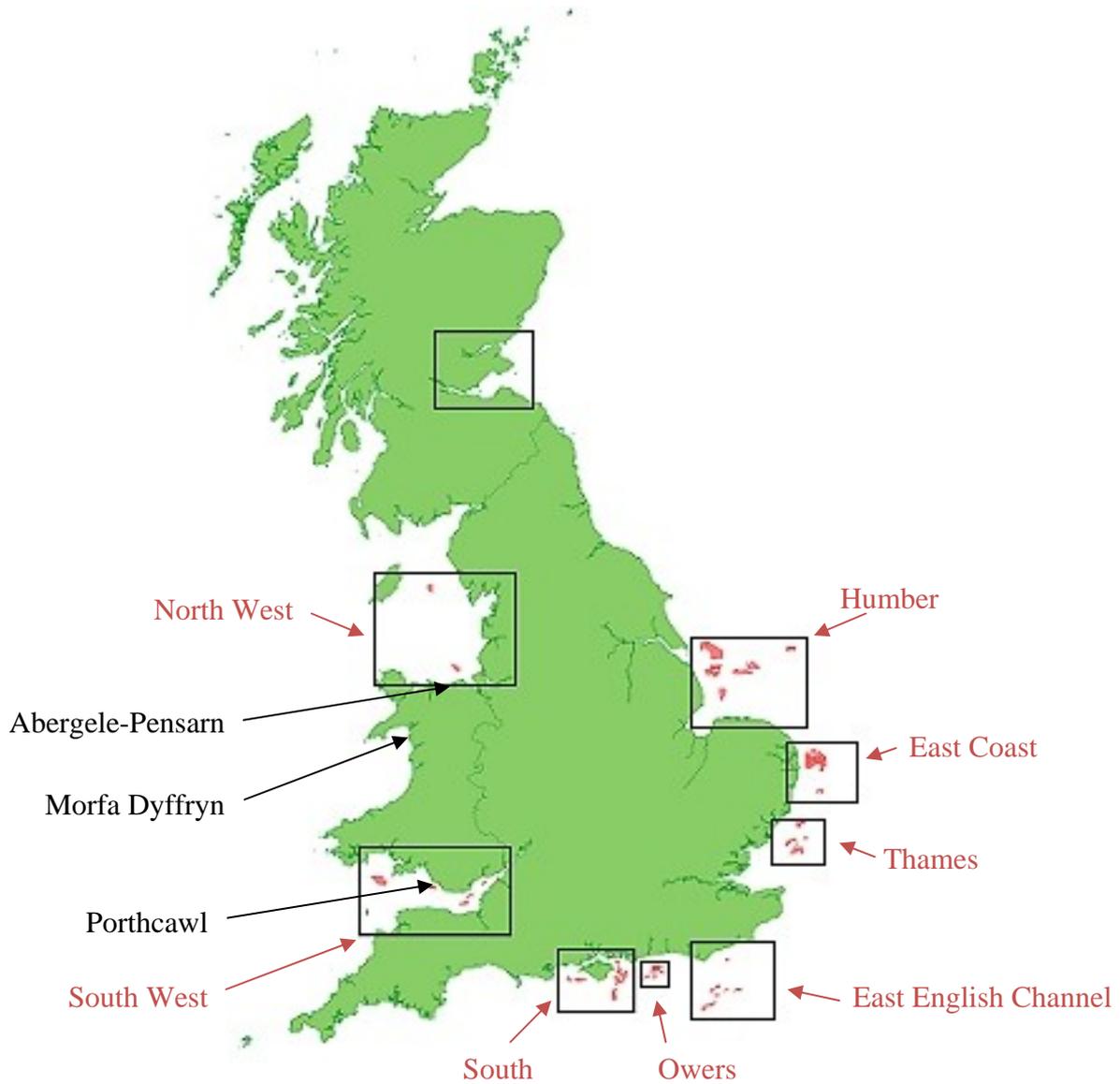


Figure 2.4- Case study sites in relation to UK Licensed Dredging Sites (source: Crown Estate, http://www.thecrownestate.co.uk/dredge_areas_statistics)

2.3.2 Results

The data for the offshore aggregate samples are lower resolution than the 60 samples taken from the case study beaches (see KPAL report in *Appendix B* for the results of this analysis). However, it is possible to draw general conclusions regarding their potential suitability as nourishment materials which might be used as beach nourishment materials to case study sites.

Values of the D50 and D90 to D10 range, the percentages of gravel, sand and mud and particle size grading curves are set out in the KPAL report in *Appendix D*, along with the data supplied by BMAPA. D50 is defined as the grain diameter of sediment that 50% of the sediment sample is finer than. D10 is the grain diameter of sediment that 10% of the sediment sample is finer than, while D90 is the grain diameter that 90% of the sediment sample is finer than.

The D50 of the Middle Ground samples is generally similar to that found on the lower beach at Trecco Bay and Sandy Bay, although the Middle Ground samples are more poorly sorted (ie have a larger D90 to D10 range). No gravel is reported in any of the Middle Ground samples

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and a separate source of such material would be needed to recharge the existing mixed sand and gravel upper beach at Trecco Bay.

Although the majority of the offshore sample from Morecambe Bay and Liverpool Bay consists of mixtures of sand and gravel in varying proportions, the grading of these samples is different from that which typifies the upper and lower beach samples at Abergele-Pensarn, with the exception of one sample described as “Concrete Sand FP” from Morecambe Bay, and one sample described as “Building Sand” from Hilbre Swash, which are similar to the lower beach sands at Pensarn.

Despite the apparent poor match between the offshore samples and the natural beach sediments, it is possible that natural processes would separate the sand and gravel fractions if the material from offshore licenced areas was deposited in the nearshore area off Abergele-Pensarn beach. It is also possible to amend and specifically target certain sediment types from a licensed area in order to better match the sediment requirements of a beach. Sediment is not uniform across a licensed area and it is possible to target dredging activities in order to target specific types / sizes of sediment. The dredging process itself can also be altered in order to target the sediment type / size required. By focussing extraction on a particular area and using appropriate dredging processes, sediment can be supplied to achieve a closer match to material on the beach.

3 THE COST OF EXTRACTING AND PLACING BEACH NOURISHMENT

This section of the Work Package investigates the costs associated with the physical extraction and placement of beach nourishment material. It does not include the cost of licenses or permissions needed to win or place the materials – this is considered in *Section 4*.

HR Wallingford Ltd. produced the report “*Beach Nourishment in Wales: Potential use of Marine Aggregate for Beach Nourishment (Report EX 6496)*” to inform this section of the Work Package. This report investigated the costs of supplying dredged material to the three case study beaches based on the amount of sediment needed for an initial beach nourishment scheme at each site. Figures for the amount of sediment required were taken from the Pilot Study and are set out in *Table 3.1*. The full report can be in *Appendix E*.

Table 3.1 – Volume and source of sediment required at case study beaches (initial nourishment only)

Case study beach	Volume of sediment required (m ³)	Source of sediment	Proportion of permitted extraction limit	Round trip distance (km)
Abergele-Pensarn	430,000	Dredge Area 392 (Irish Sea)	64% total amount until 2013	57
Morfa Dyffryn	370,000	Dredge Area 457 (Irish Sea)	46% annual limit	454
Trecco Bay, Porthcawl	160,000	Dredge Area 472 (Bristol Channel)	24% annual limit	87

Table 3.1 also provides details of the nearest licensed dredge area to the case study beach, the round trip distance and the proportion of the permitted extraction volume of the dredge area that would be needed to supply the required amount of sediment needed for beach nourishment at the case study beach.

3.1 The cost of extraction, delivery and placement of beach nourishment

3.1.1 Costs of dredging and placing material

For each of the case study beaches the dredging of material from a potential marine source and delivery to the respective case study beach using a Trailer Suction Hopper Dredger (TSHD) has been simulated using HR Wallingford Dredger Models, which use known variables related to the specific physical and operational characteristics of a dredge vessel to calculate, for example, the cycle time of the dredge and properties of the material with the dredger’s hopper. A TSHD has been used as this is the standard type of dredger used by UK marine aggregate companies.

In calculating the time it takes to deliver and discharge material at each of the case study beaches, the following assumptions have been used:

- A TSHD with a hopper capacity of around 5,000m³ is used;
- Sediment is pumped ashore from the dredger, which is moored offshore of the site;
- An approximate 6 hour window of time is allowed for the dredger to moor up and discharge its load;
- It takes approximately 70 – 85 minutes to pump ashore one dredger load of sediment (i.e. 5,000m³);

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- Plant are required onshore to redistribute the sediment as it is pumped ashore;
- A booster pump is needed at Abergele-Pensarn and Porthcawl;
- Down time (when work cannot go ahead) due to adverse weather conditions is not taken into consideration;

In calculating the costs of extraction, delivery and placement of material at each of the case study beaches, the following assumptions have been used:

- Mobilisation / demobilisation of the TSHD to / from Amsterdam is included;
- Costs associated with the direct use of the plant, including fuel, wear and tear, depreciation and interest, maintenance and repair and crew are considered. the variation in fuel costs and exchange rates present significant risk in terms of variability in these costs;
- Ancillary costs, including support equipment (booster station, pipeline, land based plant etc.) are included;
- Delivery of the pipeline to the case study site is estimated for each site - this will be highly dependant upon the length required and delivery method (road, rail, sea)
- A cost of \$900 per tonne fuel oil has been used. (Fuel costs as at April 2010 have already reached \$990 per tonne. The sensitivity of unit rate costs to fuel price increases are explored in **Table 3.5**);
- A cost of €6,000 per week is assumed for the booster station;
- Onshore plant costs of €20,000 per week is assumed for Abergele-Pensarn and Porthcawl (2 bulldozers working continuously):
- Onshore plant costs of and €10,000 per week is assumed for Morfa-Dyffryn (1 bulldozer with some down time):
- A cost of £2 per m³ for beach nourishment material has been used;
- Aggregate Levy has not been included – this is not charged on material used for beach nourishment (see **Section 4** for more information on the costs of regulatory compliance);
- An exchange rate of Euro to Sterling (£) – 1.155 has been used (Financial Times cited March 15th 2011)
- An exchange rate of has been used US \$ to Sterling (£) – 1.601 has been used (Financial Times cited March 15th 2011)

Based on the assumptions set out above, the costs set out in **Table 3.2** have been calculated for each of the case study beaches. Further detail on the assumptions and calculations undertaken can be found in the HR Wallingford report in **Appendix E**.

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Table 3.2 – Summary costs for each case study beach using TSHD (initial nourishment only)

Delivery site	Volume of recharge required (m ³)	Assumed cost of resource material (@ £2 per m ³)	Length of time to complete recharge (Weeks)	Unit cost overall (£/m ³)	Assumed cost of pipeline delivery (£)	Overall total cost per case study (£)
Abergele-Pensarn	430,000	£860,000	4.43	£7.92	100,000	£4,366,000
Morfa-Dyffryn	369,000	£738,000	15.19	£22.93	43,000	£9,243,000
Porthcawl Trecco Bay	159,000	£318,000	1.81	£8.01	57,000	£1,649,000

It is clear that Morfa-Dyffryn has a much higher overall unit cost than the other two beaches. This is largely due to the additional distance the dredger has to travel from the aggregate extraction site to the beach, leading to longer recharge times and associated vessel costs. Material from a site closer to the final location would be cheaper.

These costs are considered to be a ‘worst case’ scenario as economies of scale and, therefore lower costs, could be achieved by using a larger vessel. A 15,000m³ capacity vessel would allow higher rates of production, fewer trips and be able to pump the sediment greater distances without the need for a booster pump (over 6km). The Crown Estate and BMAPA indicate that beach nourishment projects in the UK that would need large quantities of sand would use larger vessels in the order of 15,000m³, rather than the smaller 5,000m³ vessel used in the calculations.

Table 3.3 shows how the costs for a larger TSHD (13,000m³) compare with those of a smaller vessel (5,000m³) for Morfa-Dyffryn. This shows that the length of time to complete the recharge is much reduced (to just over 1/3 of the time), but this has led to an increase in costs for on-shore plant needed to handle the increased delivery rate (2 bulldozers working full time). Further detail on the assumptions and calculations undertaken can be found in the HR Wallingford report in **Appendix E**.

Table 3.3 – Summary costs for Morfa-Dyffryn using small and large TSHD (initial nourishment only)

TSHD size (m ³)	Volume of recharge required (m ³)	Assumed cost of resource material (@ £2 per m ³)	Length of time to complete recharge (Weeks)	Unit cost overall (£/m ³)	Assumed cost of pipeline delivery (£)	Assumed Dredger mobilisation cost from Amsterdam (£)	Overall total cost per case study (£)
5,000	369,000	£738,000	15.19	£22.93	£43,000	£236,000	£9,243,000
13,000	369,000	£738,000	5.56	£15.76	£128,500	£378,200	£7,058,200

Typically the greatest costs are associated with the use of the vessel, crew and ancillary equipment. The operating overheads, risk allowance and profit also form a considerable share of the costs. The proportion of cost associated with the use of the pipeline is variable, and dependant upon the type, length and anticipated wear rate of the pipeline. **Table 3.4** shows the relative proportion of costs to these different categories.

Table 3.4 – Proportions of cost per unit rate using TSHD (initial nourishment only)

Delivery site	Overheads, Risk and Profit	Vessel Use	Fuel	Pipeline wear
Abergele-Pensarn	24%	51%	15%	10%
Morfa-Dyffryn	24%	56%	17%	2%

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Porthcawl, Trecco Bay	24%	55%	16%	5%
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The sensitivity of the unit rate costs to fuel price increases and changes in exchange rates was calculated. These are set out in **Table 3.5**.

Table 3.5 – Sensitivity of unit rate costs to fuel prices and exchange rates

Delivery site	Unit rate cost increase based on 10% increase in fuel cost	Unit rate cost increase based on 10% reduction in US Dollar -Pound exchange rate	Unit rate cost increase based on 10% reduction in Euro -Pound exchange rate
Abergele-Pensarn	2.08%	2.30%	8.93%
Morfa-Dyffryn	2.30%	2.57%	8.55%
Porthcawl, Trecco Bay	2.05%	2.38%	8.71%

3.1.2 Costs using already dredged material

Costs of beach nourishment for each case study site were also calculated using material that has already been dredged by marine aggregate producers. In this case, it is assumed that material would be transferred from the marine aggregate producer’s dredger to a split bottom barge at a location offshore of the case study site. The barge would then dump the sediment over the lower beach area at high tide. At low tide land based plant would then re-distribute the sediment across the beach to the required profile.

In calculating these costs, the following assumptions have been used:

- The cost of material supplied by marine aggregate producers is assumed to be £10 per m³.
- A load of around 1,800m³ is assumed for the marine aggregate producers’ dredger;
- Material is transferred from the marine aggregate producers’ dredger to a 2,000m³ self propelled hopper barge capable of bottom dumping. The draft of this vessel is expected to be around 4m, requiring 4.4m water depth including 10% UKC. The load within the hopper is 1,800m³.
- The vessels meet at the -10mCD contour to transfer the material;
- The barges are only be able to place material when the tidal level at the case study site is at 4.4mCD or greater;
- Consideration is made to allow for re-fuelling, crew changes and running maintenance;
- No allowance is made for downtime associated with weather conditions and adverse sea-states;
- The same rates for re-handling the material on the beaches as above have been used (see **Section 3.1.1**);

Based on the assumptions set out above, the costs set out in **Table 3.6** have been calculated for each of the case study beaches. Further detail on the assumptions and calculations undertaken can be found in the HR Wallingford report in **Appendix E**.

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The small tidal window available at the Morfa-Dyffryn site leads to significantly higher unit rate costs for the barge and overall cost. This means the barge equipment is effectively on stand by for long periods and not making deliveries as it cannot get to the beach. Savings could be made if the barge could be used elsewhere during times when it cannot access the site.

Table 3.6 – Summary costs for each case study beach using already dredged material (initial nourishment only)

Delivery site	Unit rate cost for barge placement (£/m ³)	Volume of recharge required (m ³)	Assumed cost of resource material (@ £10 per m ³)	Unit cost overall (£/m ³)	Overall total cost per case study (£)
Abergele-Pensarn	5.17	430,000	£4,300,000	£15.77	£6,785,000
Morfa-Dyffryn	33.15	369,000	£3,690,000	£45.08	£16,635,000
Porthcawl, Trecco Bay	3.18	159,000	£1,590,000	£13.55	£2,155,000

Overall unit costs are approximately 100% higher for this option (£13 - £45 per m³) compared with the TSHD option (£8 - £23 per m³).

3.2 Other sources of sediment

In addition to marine aggregates, there are three other potential sources of beach nourishment material, which are considered in more detail below:

- Materials arising from maintenance dredging;
- Materials arising from capital dredging;
- Materials from currently unlicensed marine sites;
- Terrestrial sources from quarries

3.2.1 Maintenance dredging

Maintenance dredging is usually associated with fine materials (muds and sands) and it is unusual for coarser materials to arise in large quantities. Where they do, they are typically already exploited as a resource with small scale extraction or recycling of gravels and shingles occurring at a number of UK ports and harbours. However, this is not always the case and the coastal defence scheme at Tywyn recently made use of stockpiled maintenance dredge spoil from Pwllheli harbour.

Based on information in Humphreys *et al.* (1996) on average around 40 million tonnes of dredge material per year was disposed of at 150 licensed disposal sites around the UK between 1985 and 1992. 80% of this was from maintenance dredging, however, a significant proportion of this was fine material that is unsuitable for beach recharging.

Humphreys *et al.* also provides summary information on the material types disposed of within the Bristol Channel and Liverpool Bay. The material type disposed of within the inner Bristol Channel is cohesive, fine material and is unlikely to be suitable for beach nourishment. Material disposed of in the outer Channel includes some sandy components.

Locally to the northern case study sites (Abergele-Pensarn and Morfa-Dyffryn) a significant volume of sand sized material may be obtained from the maintenance dredging of the approaches

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to the River Mersey. The typical volume of non-cohesive material available from Liverpool Bay (and particularly the approaches to the Mersey) is about 900,000m³ per year.

More recent information from Cefas provides detail on the amount of material from Welsh ports that has been disposed at sea (see **Table 3.7**). This seems to show that there is limited disposal of material arising at ports within Cardigan Bay, with only Aberaeron disposing of around 1,800 Tonnes during 2006. In the south, a significant mass of material, comparable in total mass to the disposal requirements of the Mersey Estuary, is recorded from ports such as Swansea, Cardiff and Newport. The Cefas data does not provide grading or material type (i.e. muds, sands and gravel) for the material disposed of at sea, and its appropriateness for use as beach nourishment material cannot, therefore, be deduced based solely on this information.

Table 3.7 – Dredge material from Welsh ports disposed at sea (dry tonnes)

	Year			
	2004	2005	2006	2007
Mersey Estuary	1,630,000	2,030,000	2,580,000	2,520,000
Holyhead	0	No Data	7,300	30,100
Llanon	1,830	No Data	No Data	No Data
Milford Haven	1,920	1,275	171,000	2,450
Swansea	950,000	1,430,000	771,000	1,100,000
Cardiff	240,000	299,000	262,000	217,300
Newport	262,000	282,000	346,000	207,000

3.2.2 Capital dredging

Materials arising from capital projects are usually identified during the project planning and site investigation stage. Often these materials are disposed of at sea to licensed disposal sites.

- Bristol Port Deep Sea Container Terminal (DSCT) development intends to use some of the material from the capital dredging needed to create compensatory habitat, while the remainder will be disposed of to licensed marine disposal sites in the Severn Estuary (Bristol Port Company DSCT website, <http://dsct.bristolport.co.uk/new-dsct/dredging-disposal>)
- The EIA for Pembroke Power Station proposes to dispose of material dredged as during the construction process to a licensed marine disposal site (site LU169) outside the Haven (RWE npower, 2007);
- The EIA for the Hull Riverside Bulk Terminal jetty proposes to dispose of capital dredging spoil from the construction process to licensed marine disposal sites within the Humber Estuary (Scott Wilson and ABPmer, 2010).

At the time of writing, HR Wallingford was not aware of any planned capital dredging that would yield suitable resource material that has not already been exploited as a resource. However, this does not mean that future port developments in Wales (or elsewhere) would not be a suitable source of beach nourishment material.

3.2.3 Currently unlicensed marine sites

There are a number of Active Dredge Areas (ADAs) around the UK. These are typically defined by the limits of the dredge licence, details of which are provided by BMAPA (2011) and The Crown Estate (2011). Some of these sites may be considered ‘dormant’ i.e. not currently being exploited.

Dredging application, option and prospecting areas (DAOPAs) are areas of potential resources at various stages of exploitation; from prospected to statutory application area. The Crown Estate indicates there are currently no DAOPAs in the North-West region (Irish Sea), however, there are 3 DAOPAs in the South-West - Area 455 and Area 459 are designated Statutory Application Areas, and Area 486 is currently an Application Area.

Given the proximity of Area 486 to Area 472, this resource area maybe considered a potential resource site for beach nourishment material for the Portcawl Case Study site or other South Wales beaches.

Humphreys *et al.* (1996) provides a detailed assessment of the potential beach nourishment resources in UK coastal waters. This indicates that the dominant type of marine material available is sand, with similar volumes of sand and gravel, and shingle available. A summary of their findings is set out in **Table 3.8**.

Table 3.8 – Potential marine sediment resources around Wales

Area name	Description	Resource (million m ³)	Other comments
Bristol Channel South	The area from Land's End, along the Bristol Channel to approximately the Severn Bridge	Sand - 66.9 Sand and Gravel - 10.8 Shingle - 24	
South Wales	Coastal waters around Porthcawl, Swansea and Camarthen Bay.	Sand – 134.4 Sand and Gravel – 22.1 Shingle - 6.1	
Cardigan Bay	Cardigan Bay	Sand – 28.8	There is no shingle or mixed sand and gravel resource
North Wales	The southern section of Liverpool Bay, between Anglesey and the Dee Estuary	Sand – 295.6 Sand and Gravel – 48 Shingle - 9.2	

The case study sites are likely to require material of the ‘sand and gravel’ grade. A total recharge volume for all the case study sites of just under of just under 1 million tonnes is needed. In the context of the potential resources identified by Humphrey’s *et al.* (1996) for the Bristol Channel, South Wales and North Wales of around 530Mm³ of Sand, 81 million m³ of Sand and Gravel and 39.4 million m³ of Shingle, this volume is relatively insignificant.

However, consideration should be given to the processes and timescale for application for extraction of the resource material at a new (i.e previously unlicensed site) which proving of the resource, environmental impact assessment of the extraction and potential cost associated with site investigation, management and monitoring. Some of the costs associated with obtaining consents for a previously unlicensed site are considered in Section 4.

3.2.4 Terrestrial sources

Terrestrial sources of beach nourishment material were not considered in detail at this time, however, recent experience of coastal defence schemes in west Wales at Tywyn and Borth, which included an element of beach nourishment, suggests that terrestrial sources of suitable material are available. There are a number of quarries located in Wales that might be able to supply suitable sediment, however, time constraints have not enabled this to be investigated in detail in this project.

For both the Tywyn and Borth coastal defence schemes, the successful construction contractors chose a land based source of beach nourishment material – Cefn Graianog, near Porthmadog.

Both schemes went through a full public competitive tendering process via the Sell2Wales website and different contractors were appointed for the two schemes. Some of the sediment actually used for the Tywyn scheme was eventually sourced from a stockpile of previously dredged material from Pwllheli harbour.

It is unclear why both successful contractors chose land based sources of material. It was clear that the shingle element of the nourishment would be difficult to source from a marine supply and this may have influenced the decision. Additionally, both schemes are located within Cardigan Bay and the lack of a nearby licensed marine aggregate site may have influenced the decision to choose a terrestrial sediment source, however, without further investigation this cannot be confirmed or rejected as a hypothesis.

Table 3.9 gives some approximate costs of sand and shingle per m³ for the recent coastal defence projects in Tywyn and Borth. These costs are based on the initial estimated total quantities of sediment needed and all delivery taking place by road (final amounts actually applied may be different due to quantities being revised as the designs progressed). An additional 25% would need to be added to these costs to take account of other expenses associated with the contractor’s setting up, overheads and profits.

Table 3.9 – Cost of sand and shingle from land based sources

Scheme	Total volume of sediment estimated to be needed (m ³)	Cost of sand (per m ³)	Cost of shingle (per m ³)
Tywyn	20,000	£60	£52
Borth	150,000	£45	£40

Unit costs for Borth are significantly lower than for Tywyn. This is mainly due to the greater quantity of material needed at Borth providing economies of scale. The quantities required at both sites are much lower than those needed for a beach nourishment-only scheme, however, the quantity needed for Borth is similar to that for the Trecco Bay case study beach.

These unit costs are much higher than the costs calculated for marine based sediment supplied by TSHD, even when compared with the highest cost case study beach (£23 per m³ for Morfa Dyffryn). The Borth costs are more comparable to the costs for previously dredged material for Morfa Dyffryn (£45 per m³).

3.3 Re-nourishment costs

The on-going costs of re-nourishment or ‘topping up’ of beaches with more sediment may mean that in the long run, beach re-building is more expensive than ‘traditional’ coastal defence schemes. This issue has not been investigated in any great detail, however, **Table 3.10** shows the costs of nourishment for the three case study beaches based on the calculations in **Table 2.2**. This gives the amount of sediment needed for four five-yearly renourishments to maintain a 20m berm and a 1:25 slope until 2030. It assumes a 50% loss of sediment between re-nourishments. Costs are calculated for the cost of sediment (£2 per tonne) and using the 5,000 m³ TSDH unit costs from **Table 3.2**.

It should be noted that the figures in the table are based on a number of assumptions (those set out in **Section 3.1**) and have not been adjusted for inflation or depreciation. They do not consider that various cost savings could be made, such as long term supply contracts, use of larger TSHD or use of waste materials from dredging or quarries.

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Table 3.10 – Cost of re-nourishment to 2030

Delivery site	Volume of recharge required (x 10³ m³)	Cost of material only (@ £2 per m³)	5,000m³ TSHD unit cost overall (£/m³)	Total cost to 2030 (£)	Cost per five-yearly re-nourishment (£)
Abergele-Pensarn	2,568	5,136,000	7.92	20,338,560	5,084,640
Morfa-Dyffryn	699	1,398,000	22.93	16,028,070	4,007,018
Porthcawl, Trecco Bay	546	1,092,000	8.01	4,373,460	1,093,365

As a comparison to the figures above, the approximate costs for recent coastal defence schemes in Wales are £7 million for Tywyn, £12 million for Borth and £11 million for Rhyl. In the case of Borth, the current scheme constitutes phase 1 of a larger scheme, which for the whole frontage from Borth to Ynyslas would cost in the region of £20 million.

It can be seen that over a 20 year period, beach nourishment costs seem to be on a par with the cost of a more ‘traditional’ coastal defence scheme. However, costs of both types of scheme are highly variable depending on the size and location of the beach, the design life of the scheme and the required standard of protection.

A ‘like for like’ comparison of an individual beach(es) has not been made, as this is outside of the current study remit. It is, therefore, not possible to say with certainty whether a beach nourishment or ‘traditional’ scheme would cost more over the whole life time of the scheme. Further investigations should be undertaken so that more accurate comparisons can be made.

4 REGULATORY COMPLIANCE COSTS

This section of the report investigates the costs associated with complying with the regulations associated with sourcing and placing beach nourishment material. The following sources of information have been used to determine the costs associated with regulatory compliance:

- WAG Interim Marine Aggregates Dredging Policy (IMADP);
- Marine and Coastal Access Act 2009 Impact Assessment;
- Marine Dredging EIA good practice, Royal Haskoning;
- MMO Marine Licensing Fees Consultation;
- MMO Aggregate Extraction Permissions Procedure;
- WAG Marine Consents Unit (MCU) website - <http://wales.gov.uk/topics/environmentcountryside/consmanagement/marinefisheries/licencing/?lang=en>;
- The Marine Licensing (Application Fees) (Wales) Regulations 2011, WSI 2011 no. 555 and Explanatory Memorandum;
- WAG Marine Minerals Dredging Fee Determination 2007;
- The Town and Country Planning (Fees for Applications and Deemed Applications) (Amendment) (Wales) Regulations 2009
- Notice AGL1: Aggregates Levy, December 2010, HMRC and HMRC website – www.hmrc.gov.uk
- Consultation on secondary legislation under Part 4 of the Marine and Coastal Access Act 2009: Marine Licensing – Fees, 2010, and;
- Consultation with Crown Estate, WAG Marine Consents Unit, BMAPA.

Different permissions / licenses / consents are needed for either dredging or beach management, as set out in **Table 4.1**.

Table 4.1 – Permission / licence / consent needed for dredging and / or beach nourishment / management

Permission / licence / consent	Dredging	Placing material / beach management
Dredging permission under the Environmental Impact Assessment and Natural Habitats (Extraction of Minerals by Marine Dredging) (Wales) Regulations 2007*	✓	
Food and Environment Protection Act (FEPA) 1985 (Part 2) licence*		✓
Coast Protection Act 1949 (Part 2) licence*		✓
Town and Country Planning Act 1980 permission		✓
Crown Estate / landowner consent and fees	✓	✓
Aggregates Levy	✓	
Environmental Impact Assessment (EIA)	✓	✓

* from 6 April 2011, dredging permissions, FEPA (Part 2) and CPA (Part 2) will be replaced by a marine licence under the Marine and Coastal Access Act 2009

Although not technically a licence, permission or consent, EIA has been included in the table and in the consideration of the costs of regulatory compliance as it is an important component of

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regulatory compliance and is required to accompany most of the licences / permissions / consents considered. It can also lead to substantial costs being incurred by the licence applicant.

The costs of licenses and regulatory compliance for a beach nourishment scheme can be divided into two main parts:

- Licenses and associated costs of aggregate extraction, and;
- Licences and associated costs of placing material on the beach.

The licenses and costs for these two processes are usually met by different parties. Consents and impacts assessment for dredging activities are likely to be undertaken by the holder / applicant for the dredging licence (aggregate extractors). Placement consents and impacts assessment are likely to be undertaken by the relevant local authority or other landowner.

This section only considers the costs associated with the placement of the material. The costs of licensing and compliance with regulations of aggregate extraction are incorporated into the price that the supplier provides to the end user. Details of the costs of licensing and regulatory compliance to the aggregate producer are provided in *Appendix F*.

4.1 Construction in the sea

Applications for construction projects in the sea (below Mean High Water Springs) require a marine licence.

The cost of the licence is related to the overall cost of the construction project. Fees are different in England and Wales and are set out in the relevant Marine Licensing (Application Fees) Regulations. The fees in relation to projects in Wales are set out in *Table 4.2*. Fees for non-Welsh projects are not included as beach nourishment / management projects would only fall under the Welsh Regulations.

Table 4.2 – Marine licence costs - construction projects

Band	Project cost (£)	Fee (£)	Environmental sensitivity supplement (£)
1	0 – 5,499	127	-
2	5,500 - 9,999	715	275
3	10,000 - 49,999	1,025	575
4	50,000 – 1,999,999	2,275	950
5	2 million – 4,999,999	4,525	1,350
6	5 million – 19,999,999	7,191	1,605
7	20 million – 49,999,999	12,010	1,720
8	Over 50 million	38,650	2,750

Source: Marine Licensing (Application Fees) (Wales) Regulations 2011

These costs are unchanged from the previous fees, with the exception of the addition of an extra Band for projects of less than £5,000.

Based on the costs calculated for the three case study beaches in Section 3, costs for a beach nourishment scheme could range from £1.6 million to over £16 million for the costs of material alone and are dependant on how the material is supplied. The relevant Marine Licence fees for each of the case study beaches are set out in *Table 4.3* (environmental supplements are not included).

Table 4.3 – Marine licence costs – case study beaches

	Beach nourishment needed (m ³)	TSHD costs (£)	Marine Licence fee (£)	Previously dredged material costs (£)	Marine Licence fee (£)
Abergele-Pensarn	430,000	£4,366,000	4,525	£6,785,000	7,191
Morfa Dyffryn	369,000	£9,243,000	7,191	£16,635,000	7,191
Porthcawl: Trecco Bay	159,000	£1,649,000	2,275	£2,155,000	4,525
Total	958,000	15,258,000	13,991	25,575,000	18,907

Table 4.3 shows that as the overall cost of the project increase, the licence fees also increase. It is also clear that the licence fee costs are insignificant when compared to the cost of supplying the sediment for the scheme (less than 1%).

Timing

According to the WAG MCU website, it normally takes at least 10 weeks to process an application, however, some applications may take longer, such as large projects, those involving the placement of large amounts of material or those in / near to conservation areas, particularly where an Appropriate Assessment is needed. As most of these conditions are likely to apply to beach nourishment projects in Wales, it is safe to assume that applications will take longer than 10 weeks to progress and an allowance of 20 weeks should be made.

4.2 Planning Permission

For beach nourishment schemes, either alone or in combination with other beach management measures (i.e. built defences), planning permission under the Town and Country Planning Act (TCPA) 1980 may be required, for elements of the scheme that are above Mean Low Water (MLW).

Schedule 1 of the Town and Country Planning (Fees for Applications and Deemed Applications) (Amendment) (Wales) Regulations 2009 sets out the level of fees for different categories of development. Beach nourishment / management schemes are likely to fall under category 9(b):

“9. The carrying out of any operations not coming within any of the above categories (b) in any other case, £166 for each 0.1 hectare of site area, subject to a maximum of £250,000.”

The upper limit relates to schemes over approximately 150 hectares (1.5 million m²).

Table 4.4 shows the area of backbeach for each of the 10 Pilot Study beaches, calculated as part of this Phase 2 study (see **Section 2.2** and **Appendix C**). The three case study beaches are highlighted in yellow. The backbeach is defined as being the area between Mean High Water Springs (MHWS) and Highest Astronomical Tide (HAT). As the TCPA applies down to MLW, it is possible that a larger area could be subject to planning permission for beach nourishment.

Table 4.4 –Planning permission costs for each of the Pilot Study beaches

No.	Beach	Frontage length (m)	Backbeach area (MHWS to HAT) (x10 ³ m ³)	Planning permission fee (£)
1	Talacre	2,880	44.3	73,538
2	Abergele-Pensarn	2,650	21.8	36,188
3	Traeth Crugan	1,700	10.7	17,762
4	Morfa Dyffryn	5,000	82.0	136,120
5	Aber Dysynni to Tywyn	3,360	22.1	36,686
	Tywyn to Aberdovey	4,880	26.3	43,658
6	Tenby North Beach	790	5.2	8,632
7	Port Eynon	1,200	18.7	31,042
8	NW Swansea Bay	4,770	67.8	112,548
9	Baglan-Aberavon	4,720	73.7	122,342
10	Porthcawl: Sandy Bay	670	13.9	23,074
	Porthcawl: Trecco Bay	720	10.2	16,932
	Total			658,522

4.3 EIA costs

Under Council Directive on the assessment of the effects of certain public and private projects on the environment (85/337/EEC - the EIA Directive), Annex II lists projects that may be subject to EIA. This includes:

“(k) Coastal work to combat erosion and maritime works capable of altering the coast through the construction, for example, of dykes, moles, jetties, and other sea defence works, excluding the maintenance and reconstruction of such works.”

This is most likely to apply to works where beach nourishment will be carried out in combination with other beach management activities (i.e. building of structures such as groynes, breakwaters). It could also be applied to beach nourishment only, particularly in areas that are environmentally sensitive.

Given the extensive coastal coverage of European protected sites in Wales the majority of areas where beach nourishment could be used are likely to need an EIA (or at least screening / scoping).

An EIA is likely to be required for schemes that require either or both marine consent and planning permission. However, where both terrestrial and marine consents are needed, one EIA can cover both applications.

Recent experience on coastal defence projects in Wales which require a combination of built structures and beach nourishment suggests that the cost of an EIA in / near EU protected sites, where there is a good level of understanding and background data are in the region of **£75,000 - £100,000** and take at least **9 - 12 months** to complete. Costs would be more if additional survey work is required (e.g. boat-based marine survey, bird surveys, marine mammal survey, etc.).

4.4 Total costs

Based on the findings set out in the sections above the cost of regulatory compliance has been calculated and is set out in **Table 4.5**. The following assumptions have been made:

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- Each case study beach requires both a marine licence and planning permission for beach nourishment;
- The marine licence fee costs are based on the costs of the project (i.e. the amount of sediment required - see *Section 3*);
- Each case study beach requires an EIA to accompany its marine licence and planning permission applications;
- The cost of an EIA is estimated to be £100,000;
- The following costs are not included:
 - Sediment;
 - Scheme design;
 - Project Appraisal Report (PAR) (or similar) production;
 - Staff costs for the Local Authority or other scheme ‘sponsor’;
 - Survey work to support the EIA;
 - Amendments to Crown Estate / landowner fees for the area of shore covered by the scheme.

Table 4.5 – Total licensing costs for case study beaches

Beach	Beach nourishment needed (m ³)	Marine Licence fee (TSHD supplied material) (£)	Marine Licence fee (Previously dredged material) (£)	Planning permission fee (£)	EIA costs (£)	Total* (£)
Abergele-Pensarn	430,000	4,525	7,191	36,188	100,000	143,379
Morfa Dyffryn	369,000	7,191	7,191	136,120	100,000	243,311
Porthcawl: Trecco Bay	159,000	2,275	4,525	16,932	100,000	121,457
Total	958,000	13,991	18,907	189,240	300,000	508,147

* Total costs use the highest Marine Licence fee costs i.e. for previously dredged material

EIA and planning permission costs make up the largest elements of the regulatory costs for a beach nourishment scheme. These costs would, however, be incurred whether the scheme was for beach nourishment or any other type of coastal defence improvement scheme.

Overall, the cost of all the licences and permissions (including EIA) needed for a beach nourishment scheme is minimal when compared to the overall cost of the scheme itself (i.e. the cost of the sediment). For larger schemes (Abergele-Pensarn and Morfa Dyffryn), total licensing costs are between 1.4% and 3% of the cost of the sediment required (depending on the source). For a smaller scheme, such as Trecco Bay, total licensing costs are a greater proportion of the total costs (between 5.6% and 7% of the cost of sediment). This suggests that in order to get the greatest value for money, beach nourishment schemes should seek to place as much sediment as possible in a single project.

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Given that beach nourishment is not a permanent solution and will need to be replaced every 5 – 10 years applying more than the minimum amount needed during the initial nourishment could also increase the period between re-nourishments. This would lead to a larger cost project and thus an increase in Marine Licensing fees. However, such an increase in fees is minimal when compared to the overall cost of the sediment required (see *Section 4.1* above).

Alternatively, a long-term license that enables more regular, smaller re-nourishments could also deliver similar licensing value for money. Such licences may not be appropriate for all schemes / locations but could be an option to explore at certain locations with conditions similar to Trecco Bay, which require relatively small amounts of nourishment.

The Pevensey Bay Sea Defences scheme is a long term (25 year) scheme that sees regular annual nourishment of the beach supplemented with recycling of built up material on the beach as and when needed (usually three times a year and / or after heavy storms). At Pevensey it was found that larger renourishments were not cost effective because the surplus was quickly washed away.

As discussed above, placing smaller amounts of material is generally more expensive, but if a long term arrangement could be made with a supplier / contractor, this could help to achieve cost savings. Opportunities for long term or flexible licences should be investigated in more detail with WAG MCU. The Pevensey and Lincshore projects could provide useful case studies to examine in more detail to see what lessons can be learned for longer term (20+ years) beach nourishment projects.

5 CONCLUSIONS & RECOMMENDATIONS

5.1 Conclusions

Beaches in Wales fall into only a few categories. Most are classified as ‘fringing’ beaches, although there are a large number of small ‘pocket’ beaches. The majority of Welsh beaches are comprised of a shingle upper beach with a sandy lower beach, although a significant proportion is either only sandy or only gravelly. 90% of Welsh beaches fall within one of these three sediment type categories.

It is difficult to draw any general conclusions regarding the quantity of sediment needed as this varies depending on the beach, its current slope, width, length and the profile to which the beach is to be nourished and maintained and the length of time over which it is to be maintained. Estimates range from 10,000m³ to 2.5 million m³ for just the three case study beaches (for up to 100 years).

The quantities of material are large but when considered against the quantities available on the seabed (up to 295 million m³ sand off the North Wales coast), it becomes apparent that such quantities are present around the coast of Wales.

Material from marine aggregate sites near Wales (in the Bristol Channel and Irish Sea) are similar to some sections of Welsh beaches. They correspond most closely to sandy beaches or to the sandy parts of mixed beaches. Marine aggregates do not match the more gravelly beaches / parts of beaches well at all. This is not to say that marine aggregates could not supply suitable gravel, just that the current sediment dredged from these sites does not match. The Crown Estate has indicated that there are suitable licensed sources available and that several marine aggregate producers are able to supply these types of sediment.

In considering the costs of material, the way in which they are sourced and supplied has a considerable impact on the total project costs. Material supplied to a scheme by a marine aggregate producer is approximately twice the cost of material supplied directly by a contracted TSHD. Vessel use costs make up the greatest proportion of the cost of material supplied by a contracted TSHD. This means that scheduling to reduce down time and sourcing material from a close to the beach nourishment site as possible will have a significant impact on reducing the total costs of any beach nourishment scheme. Further cost reductions could also be achieved by using a larger vessel capable of carrying larger quantities of sediment and, therefore, needing to make fewer trips. The costs within this study have been calculated using a relatively small 5,000m³ vessel, which give a ‘worst case’ scenario. A 15,000m³ vessel would be able to carry three times the amount of material and would need to make fewer trips. A larger vessel may also be less constrained by tides, being able to pump sediment ashore from a greater distance.

When comparing the costs of beach nourishment over 20 years to a more ‘traditional’ coastal defence scheme, total costs appear to be on a par, however, costs for both types of scheme vary considerably depending on the size, location, design life and standard of protection needed. A ‘like for like’ comparison was not carried out due to time and resource constraints. Further work could prove useful in demonstrating the relative costs of the different approaches.

The use of maintenance and capital dredging spoil could further significantly reduce the cost of beach nourishment. This material may not be suitable for beach nourishment as maintenance dredge spoil in particular tends to be made up of smaller grained sediment (fine sand and mud),

which may be unsuitable for many beach nourishment projects. It may, however, be useful for schemes that are designed to feed wind-blown dune systems.

Capital dredge spoil could potentially supply large amounts of material, but such activities do not occur regularly.

Terrestrial sources of suitable sand and gravel are available from within Wales, however, little information on the quantities or costs of this material for beach nourishment is available. A brief review of the Regional Technical Statements for both the North Wales and South Wales Regional Aggregates Working Party (RAWP) suggests that beach nourishment is not considered in any detail as a potential end user of land based aggregates. Time and resource constraints prevented further investigation of this potential source.

The costs of sourcing and placing marine aggregates for beach re-building are by far the greatest proportion of the total costs of any beach re-building scheme. The costs of licensing to carry out a scheme are much less than 10% of the overall costs. EIA and planning permission costs account for the greatest proportion of licensing costs. As could be expected, the costs of licensing larger schemes are greater than for smaller schemes, however, the increase in the costs of licensing are not proportional to overall scheme costs. The greatest value for money can, therefore, be achieved by seeking to place as much sediment as possible in a single project. This may also increase time between re-nourishments and reduce long-term costs. There are risks to placing a larger than needed amount of sediment on the beach, such as increased risk of smothering of habitats and species and increased rate of loss of sediment (potentially a ‘false economy’).

Alternatively, a longer-term license (20+ years) that enables more regular, smaller re-nourishments could also deliver similar licensing value for money. Long term arrangements with suppliers / contractors to service such licencing arrangements could also help achieve cost savings. The relative life time costs of these different approaches has not been explored in any detail, however, similar schemes elsewhere in the UK, such as at Pevensey and Lincolnshire could provide useful case studies to examine in more detail.

5.2 Recommendations

The following recommendations are made, based on the findings of this review and comments from the Steering Group:

- A more accurate understanding of the marine resource available off the coast of Wales is needed, particularly in relation to the availability of larger sized sediment (shingle, gravel, cobble) and particularly in relation to resources to the west of Wales.
- The use of maintenance dredging spoil from the many small harbours and marinas around Wales should be further investigated, including the quantities available, sediment type, potential contaminants and possible matches to suitable beach nourishment locations made.
- Efforts should be made to identify upcoming projects with a capital dredging element and investigations into the suitability of the material being removed for beach nourishment should be undertaken.
- The potential of land based aggregates to supply suitable material for beach nourishment, particularly for the larger, gravel and cobble fractions required

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should be investigated further with the Welsh RAWPs. Implications for minerals planning and the production of national safeguarding maps for minerals, which are being developed by WAG, need to be considered if beach nourishment is likely to be a potentially significant user of land based minerals.

- The use of waste minerals should be investigated with the Environment Agency and WRAP to determine if secondary sources of material are appropriate for beach nourishment.
- The whole life costs of beach nourishment versus ‘traditional’ schemes should be investigated in more detail.
- The possibility of using longer term licenses (20+ years) that allow regular small nourishments should be explored with WAG MCU.
- The relative costs of regular small nourishments versus less frequent larger nourishments should be explored in more detail. Pevensey and Lincshore could provide useful case studies from other parts of the UK.
- The sustainable and long term supply of marine aggregate for beach nourishment should be taken into account when developing a marine plan(s) for Wales (and other parts of the UK).

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